UTTAR PRADESH
SCIENTIFIC RESEARCH COMMITTEE MONOGRAPH

THE BRASS INDUSTRY IN UTTAR PRADESH

S. S. KHANNA

739
K B

3169

THE BRASS INDUSTRY IN UTTAR PRADESH

S. S. KHANNA

739
K B

UTTAR PRADESH
SCIENTIFIC RESEARCH COMMITTEE MONOGRAPH

UTTAR PRADESH
SCIENTIFIC RESEARCH COMMITTEE MONOGRAPH
NUMBER-7

General Editor
PROF. SATYA PRAKASH, D.Sc., F.A.Sc.

THE BRASS INDUSTRY IN UTTAR PRADESH

THE BRASS INDUSTRY IN UTTAR PRADESH

INVESTIGATIONS INTO THE REORGANISATION ON SCIENTIFIC LINES OF THE BRASS INDUSTRY OF VARANASI, MORADABAD AND MIRZAPUR

S. S. KHANNA
Dr. Ing.
Reader in Met. Engg., College of Mining and Metallurgy,
Banaras Hindu University.

ASIA PUBLISHING HOUSE
BOMBAY · CALCUTTA · NEW DELHI · MADRAS
LOCKNOW · LONDON · NEW YORK

© SCIENTIFIC RESEARCH COMMITTEE
GOVERNMENT OF UTTAR PRADESH
1963

739
K B

राज्य संग्रहालय पुस्तकालय, लखनऊ
क्रम संख्या 3769
प्राप्ति तिथि 15-3
State Museum, Library, Lko.

PRINTED IN INDIA
BY J. K. SHARMA AT THE ALLAHABAD LAW JOURNAL PRESS
ALLAHABAD AND PUBLISHED BY P. S. JAYA SINGHE
ASIA PUBLISHING HOUSE, BOMBAY

FOREWORD

In 1947, the Uttar Pradesh Government, largely on the initiative of Dr. Sampurnanand, then Education Minister, set up a Scientific Research Committee, U.P., for the promotion of the scientific research within the State. Since then, on the recommendations of the Committee, Government have been financing a number of research projects in the fields of fundamental and applied sciences at the Universities, as well as at some non-university institutions in the State.

In spite of limited finances, this pioneering idea has paid ample dividends in keeping alive a spirit of enquiry and investigation in new frontiers of knowledge and in training research personnel who are now helping in the Second and Third Five-Year Plan developments in the State and outside it.

In 1959, the reconstituted Scientific Research Committee decided at a meeting, in which Dr. Sampurnanand, Chief Minister, was present, that time had come when a consolidated account of the progress achieved by the Committee could be published for general information and for the benefit of those who are engaged in similar fields of endeavour in other parts of India. Accordingly, a series of monographs written by specialists in their respective fields have been prepared and are being published. It is to be hoped that this effort will be welcomed on all hands and will prove useful to readers.

Chhattar Manzil Palace,
Lucknow
May 19, 1960

B. MUKERJI
Chairman,
Scientific Research Committee
Uttar Pradesh

ACKNOWLEDGEMENT

THE author is thankful to Dr. D. Swarup, Ph.D. (Sheffield), Principal, College of Mining and Metallurgy for his kind guidance and valuable help at the various stages of this research work.

Acknowledgment is also given here to the help obtained from the following officers, firms and technicians :

1. Prof. V. G. Iyer, College of Mining and Metallurgy, Banaras Hindu University.
2. Mr. U. S. Srivastava, Proprietor, National Malleable Castings, Assi, Varanasi.
3. Mr. Kapoor, General Manager, Himalaya Metal Works Company, Moradabad.
4. Mr. B. K. Ghoshal, Director of Cottage Industries, Uttar Pradesh.
5. Mr. M. Z. Rab, Asstt. Director of Industries, Uttar Pradesh.
6. Mr. Prem Nath, Proprietor, Kedar Engineering Works, Moradabad.

VARANASI
May 2, 1962

S. S. KHANNA

CONTENTS

PART A–GENERAL STUDY

I. Introduction 1
Survey of the Brass Industry in Uttar Pradesh 2
II. Treatment of "Secondary Brass" 9
Manufacture of Standard Alloys 15
Brass Rolling-Factory Lay-out 20

PART B–METALLURGICAL STUDY

III. Chemical Analysis of Typical Samples .. 31
Microscopic Examination 35
IV. Tinning Copper and Brass 47
V. Permanent Moulds 54

PART A

GENERAL STUDY

CHAPTER I

INTRODUCTION

BRASS Industry in Uttar Pradesh is one of the main cottage industries and has got a great future. The development of cottage industries are bound to play a great and important part in shaping the national economy of our country. They will produce a considerable proportion of consumers' goods and at the same time, provide employment to a very large number of workers in all parts of India as will be evident from the following table :*

Provinces	*Total workers*	*Factory workers*	*Non-factory workers (cottage lines)*
Bengal	1234	563	671
Bombay	931	509	422
Madras	2088	194	1894
U. P.	2478	155	2323
Bihar & Orissa	989	98	891
C. P.	575	62	513
Punjab	1412	72	1340

In India we have many metal works on cottage industry lines, but unfortunately they are so poorly planned and organised that they hardly provide two square meals per day to the workers, who labour day in and day out.

---

* By Dr. V. K. R. V. Rao, Ph.D. (Cantab), University Professor of Economics, Delhi.

We have always looked down upon these industries; setting little value on them. If cottage industries are organised on proper lines and scientific methods of manufacturing are adopted it will be very paying. In these days of scientific discoveries and inventions the process of manufacture changes daily. Such a rapidly changing world has no place for crude and primitive methods. Nature does not want to keep alive those who do not want to move forward. Some of our old industries have already disappeared and others are disappearing only because of their reluctance to keep pace with the march of time.

The paramount difficulty in the brass metal industry of Uttar Pradesh is the poor productive technique; the existing methods and implements in a number of cases have descended from the hoary past and still retain the form and shape which they first received centuries ago. It is of course not possible for the artisan to think of improving either his implements or his technique on his own. The others who should be interested in doing so have not bothered very much, while engineers and scientists have their fancies drawn towards the lure of large-scale industries. *It must also be added that improving the artisan's technique is not enough; the improved technique has got to be popularized and the artisan induced to undertake it. Demonstrations, touring classes and exhibitions are some of the methods that can be employed and State help and initiative seem to be an indispensable preliminary.*

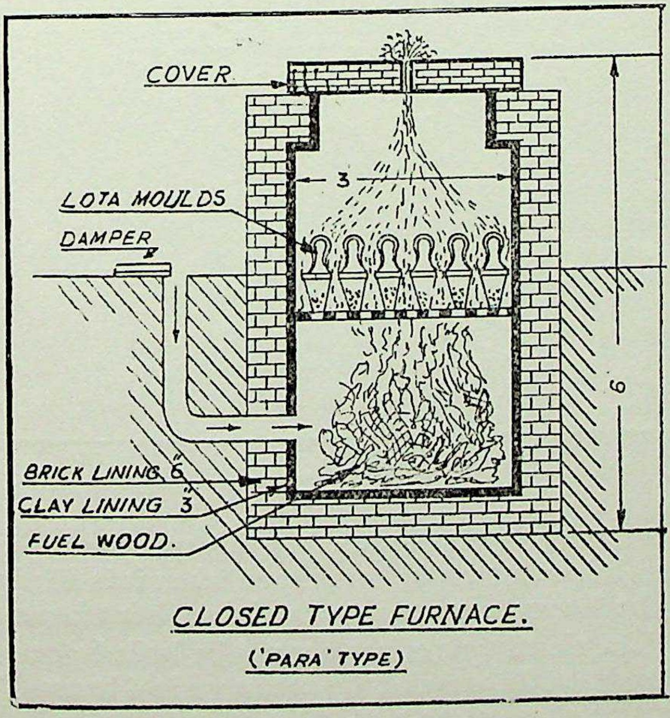
SURVEY OF THE BRASS INDUSTRY IN UTTAR PRADESH

1. Brass is an alloy of copper and zinc in varying proportions. There are no specifications either asked or quoted as regards the physical properties and chemical compositions of the brass that is being imported into Uttar Pradesh.

2. The other raw materials used in the industry are:

   (a) *Virgin metals* : Copper, zinc, tin and lead
   (b) *Brass scrap and other brass alloys* : Broken utensils, cartridge cases, brass borings and brass sheet.
   (c) *Fluxes and colouring materials* : Charcoal, borax and common salt
   (d) *Fuel* : Wood, coal and coke
   (e) *Solders* : Alloys of (Pb, Sn and Sb)
   (f) *Moulds, crucibles and bricks* for lining the furnace
   (g) *Electric Power*

3. *Furnaces* : There are two main types of furnaces used in the melting of brass in the State. No endea-


COVER
LOTA MOULDS
DAMPER
3
6
BRICK LINING 6"
CLAY LINING 3"
FUEL WOOD.

CLOSED TYPE FURNACE.

('PARA' TYPE)

Fig. 1

vour has been made to improve the construction and efficiency of the furnaces. The first, that is, the closed type (Fig. 1) is deep and is used for big castings only. In this, the ash etc. is removed after the alloy has melted and the furnace is cooled. The other type also called the Open Type Furnace (Fig. 2) is a shallow furnace made in the form of small hearths. In this type the ash is collected below in the wind vessel and when it is filled with ash, the fire grates are removed and the ash is taken out.

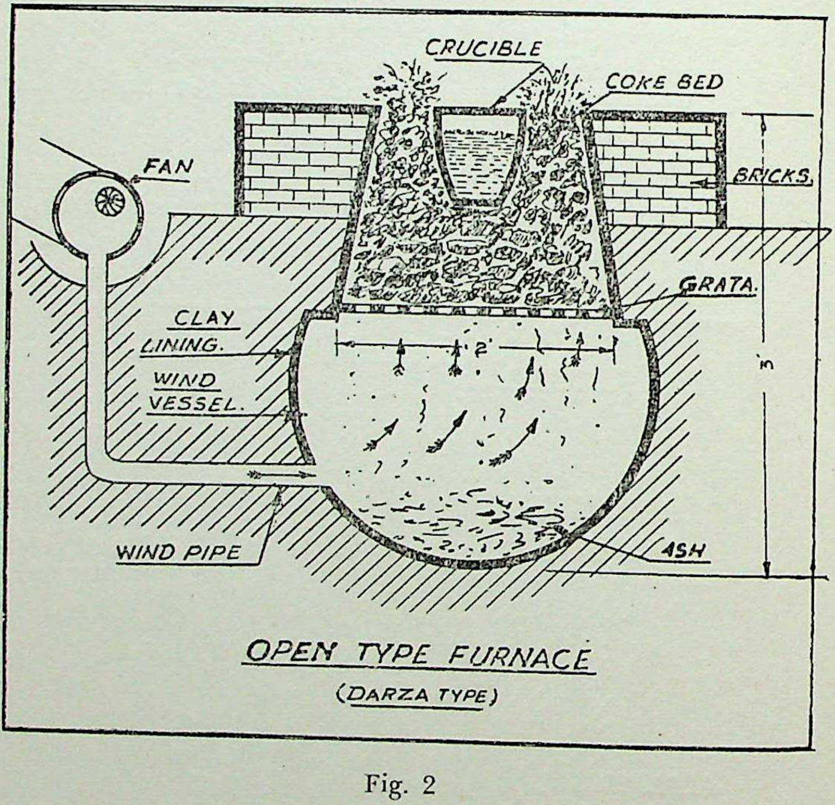

CRUCIBLE
COKE BED
FAN
BRICKS.
GRATA.
CLAY LINING.
WIND VESSEL.
2'
1'
WIND PIPE
ASH
OPEN TYPE FURNACE
(DARZA TYPE)

Fig. 2

The closed type of furnace can be built by one man in one day of 8 hours and the open type in 4 hours. The repairing charges are negligible. Ordinary bricks are used in the construction.

The other types of furnaces like "Dove type" and coke fired forced draught furnace are used in rolling mills only.

4. *Casting* : There are two types of castings :
   1. 'Para'* casting—A process of casting in which earthen mould is used.
   2. 'Darza' casting—Casting in the iron mould using a mixture of sand, ash, oil and used for casting of all the luxurious articles.

Lota and *Gillas* (round jugs and tumblers) which are two articles manufactured by far in the largest quantity in the State are manufactured by 'Para' casting process. Fig. 3 shows the 'Para' casting mould of *Lota* and how the crucible is attached to it.

The procedure adopted is very crude and wasteful. The extra metal used and the cost of machining raise the cost and leave a very small margin of profit.

5. *Sheet Products* : Foreign sheets are now practically non-available owing to import difficulties; its place has been taken by country made sheets. Brass sheets are used for the manufacture of household utensils, trays, wares, jugs, tumblers etc. Fabricated articles are becoming popular.

6. There is not a single large-scale rolling mill or press plant in the State so far, except some small rolling mills at various places.

7. The manufacture of brass and copper wares provides employment to about sixty thousand people. Estimated output is about 5 to 6 lakh maunds per year.

8. The consumption of brass ware in Uttar Pradesh is about 6,000 tons a year.

9. The important centres of the brass industry are : Mirzapur, Varanasi and Moradabad.

10. *Survey of the above three centres.*

---

* These are the local names in the industry.

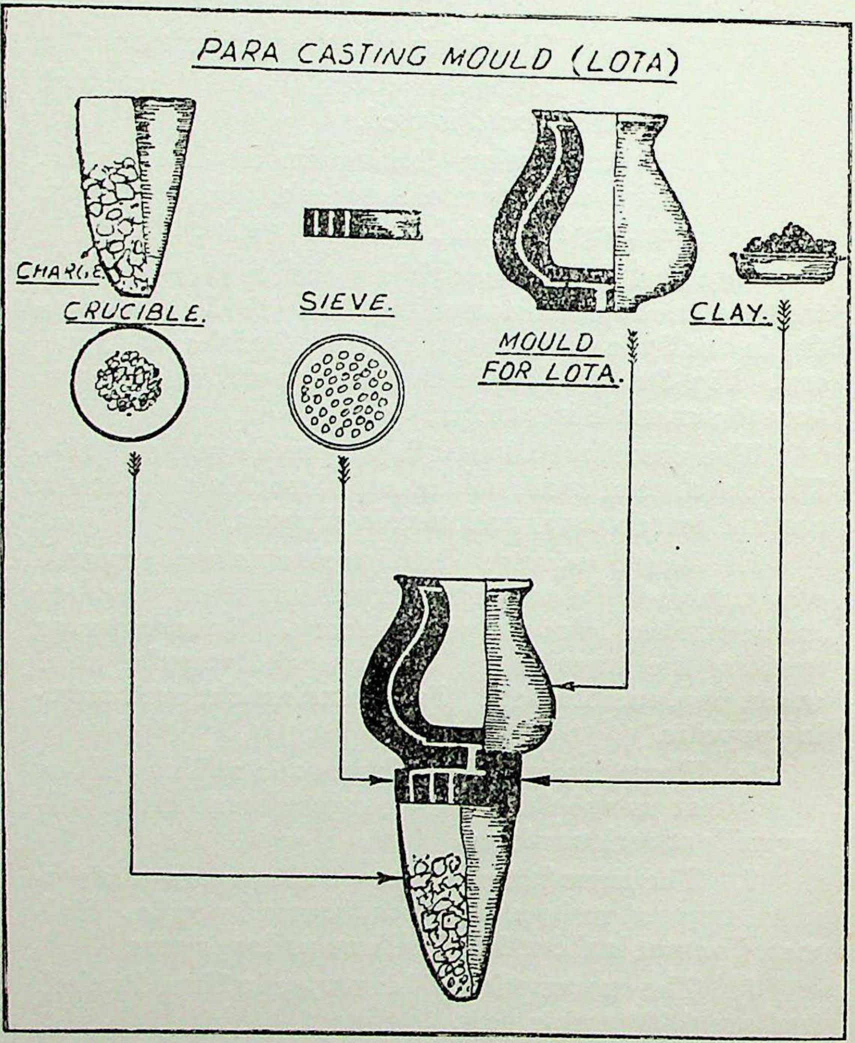

PARA CASTING MOULD (LOTA)
CHARGE
CRUCIBLE.
SIEVE.
MOULD
FOR LOTA.
CLAY.

Fig. 3

Mirzapur : It is the biggest centre of Brass Industry in Uttar Pradesh. The annual export and import figures are given in the following table :

Material	*Export of articles in maunds*	*Import of metals and scraps in maunds*
Brass	1,56,000	4,00,000
Copper	2,400	20,000
Spelter and Zinc	2,300	60,000

The brass sheets are obtained from Bombay and Calcutta; besides this, there are 26 rolling mills at present.

Varanasi : It is the third biggest centre of the Brass Industry in Uttar Pradesh. The annual production is 20,000 maunds. There are some 500 foundries in Varanasi and its suburbs. In the city, Chowk Ward (Bholetan, Kashipura, Hakkatola, Harka, Thatteri Bazaar etc.) is an important centre. Suburban foundries are situated in the outskirts of Banaras Hindu University (Khojawa, Sarai Nadan, Aditya Nagar, Nabada, Sundarpur etc.). About 9 to 10 thousand men are engaged in this industry. Some of these foundries cast bronze, copper, aluminium and German silver utensils. The output is nearly 10,000 maunds. In general the industry is in scattered form and not well-organised.

Moradabad : It is estimated that 20 % of the total production at Moradabad is of ornamental brass-ware articles, 70 % is domestic utensils and 10 % is cutlery and electroplated nickel-silver.*

The annual out-turn is estimated at about 40,000 mds., the price of which is Rs. 3 crores nearly. The raw materials used are nearly 10,000 maunds of scrap and 10,000 maunds of pure copper and zinc. About 25,000 persons are employed in the industry. There are about 250 small factories and in each factory there are about 8 to 30 workers employed, while 5,000 to 6,000 workers are working independently. The daily average income is Rs. 1|8|- to Rs. 3|8|- per head. The annual coal consumption is 600 tons nearly.

---

* From Report by M. Z. Rab (1944).

The annual out-turn is approximately Rs. 160 lakhs worth of domestic ware, Rs. 50 lakhs worth of ornamental wares and Rs. 20 lakhs worth of electroplated nickel-silver and cutlery articles.

About 2,000 workers are employed in the manufacture of electroplated nickel-silver and cutlery articles. In ornamental goods the workers engaged are 5,000 approximately. (These figures have been obtained from the Office of the Director of Cottage Industry, U.P.).

*Existing Machinery and equipment*** :

The following table gives a complete idea of the Brass Industry of Moradabad and its importance in the Province.

S. No.	*Name of machines*	*No. of machines*
1.	Polishing machines	225
2.	Scraping machines	85
3.	Spinning Lathes	34
4.	Silver and Nickel Plating Tanks units	80
5.	Brass Sheet Rolling Mills	8
6.	Power Presses	5
7.	Hand Presses	25
8.	Punching machines	10
9.	Tilting Furnaces	2
10.	Finishing of Tinning (Motors)	150
11.	Drilling Machines	20
12.	Frosting Machine	1
13.	Diesel Engines	19
14.	Electric Motors	418
15.	Dynamos	100

** Report by R. D. Saxena, Industrial Inspector, Bareilly Circle, U.P.

CHAPTER II

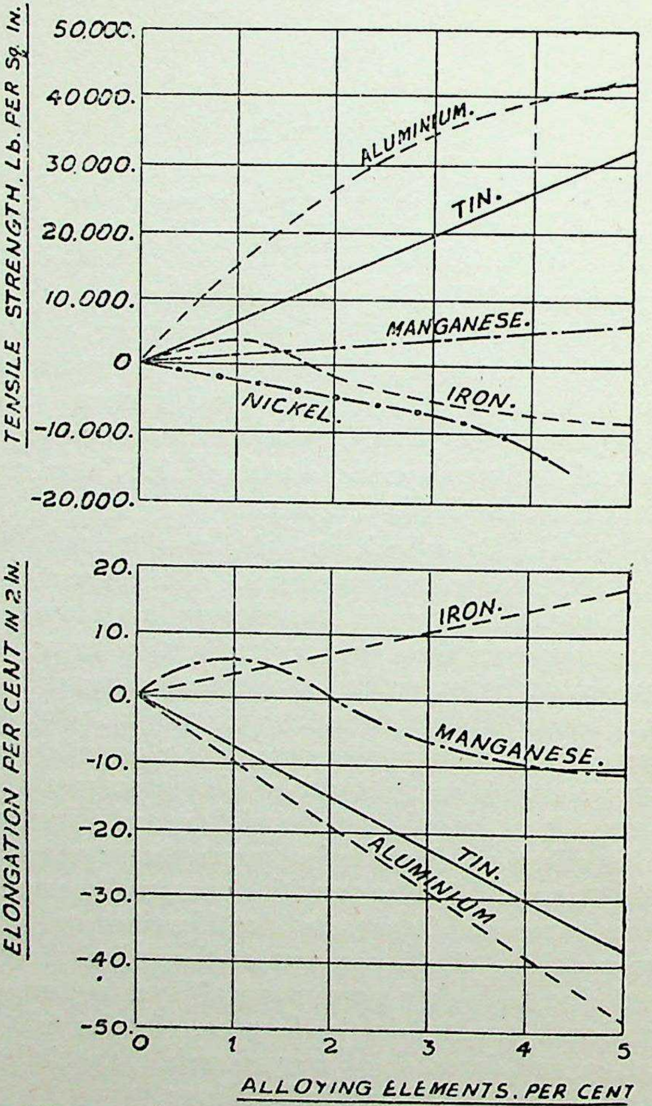
I. TREATMENT OF "SECONDARY BRASS"

IN the interest of a healthy national economy every country is striving for a state of self-sufficiency particularly in its mineral requirements. The experiments in the Soviet Union have been attended by great success. Proper planning converted Russia, an agricultural country into a first rank industrial one. Russia of 1917 was not far different from the India of today.

The chief draw-back in this brass industry is an unscientific choice of raw materials. The scrap that they utilise is obtained from various sources in various forms. It is necessary to make a proper classification far unlike in ferrous scrap, the impurities-present in brass are not easily eliminated. Hence, the purity of scrap is a vital factor. The scrap is always contaminated with a certain amount of impurities. The chief impurities in scrap are iron, lead, tin, nickel, arsenic and aluminium and these have a harmful effect on the physical properties, as shown in Fig. 4. Iron and lead impurities are usually associated with the scrap and hence, its identification is necessary before melting. 30-35 per cent of the rolled sheets are cracked due to higher percentage of iron and are thus rejected and remelted in the furnace. In the matter of collection and despatch of raw materials, the following tests would give the correct indications :

1—RAPID IDENTIFICATION OF NON-FERROUS SCRAP

In spite of the care taken to segregate different kinds of scrap, mixups are likely to occur. The following tables



EFFECT OF ALLOYING ELEMENTS ON PROPERTIES OF 60-40 BRASS.

Fig. 4

enable the identification of such scrap to be carried out rapidly and accurately. Since in most cases, the scrap to be identified will be known to be one of two materials, all that is necessary to do is to follow the data for both materials in the tables until a test is located in which the two materials behave differently.

TABLE I

Material	*Surface appearance*	*Magnet Test*	*Lathe Chip Test*	*Blow pipe Test*
Nickel	Dark grey, sometimes green (oxide)	Magnetic.	Cuts easily smooth edges, continuous,	Melts slower than steel; less slag than monel; quite nel; quite puddle.
Monel	Dark grey smooth.	Slightly magnetic at Room temp.	—do—	—do— Considerable slag; quite puddle.
Nickel silver.	Grey to yellow or yellowish green.	Non-magnetic.	Smooth, long, often continuous.	Moderate melting speed, fumes.
Brass	Yellow to green or brown.	—do—	Smooth long chips more brittle than copper.	Moderate melting speed, gives off fumes, puddles like water.
Aluminium bronze.	Yellowish Brown.	—do—		
Copper	Smooth, red brown to green (oxide).	—do—	Smooth, long, easily cut chips.	Slow melting very little slag. Puddle bubbles.
Aluminium	Light grey to white, dull or brilliant.	—do—	Smooth chips, sharp edges where cut, chips can be continuous.	Very fast melting; quite black scum forms quite puddle.
Magnesium alloys.	White surface coating may be yellow brown.	—do—	Short, easily cut chips.	

Lead	Smooth, velvety white to grey.	non-magnetic	Cut by knife any shape chips.	Melts very fast. Quiet slag, Dull grey coating, quite puddle.
Lead—silver solder.	Smooth dark grey sometimes discontinued.	—do—	Harder than lead. Any shape chips.	Slower melting than lead and lead-tin.
Lead-tin solder.	Smooth white to grey, may be frosty.	—do—	—do—	Faster melting than lead-silver about same as lead.

TABLE II

Material	*Nitric Acid*	*Iron nail Test*	*Ammonia Test*	*Others*
Nickel	Reacts slowly, pale green solution.	Negative	Blue	Test No. 4 Intense red colour.
Monel metal.	Reacts, Greenish, Bluish solution.	Copper plates out.	Dark blue.	Test No. 4. Intense red colour.
Nickel silver.	Reacts bluish green solution.	—do—	—do—	Test No. 4. Red colour varies in intensity with nickel content.
Brass	Reacts vigorously green solution.	Copper plates out.	Dark blue.	Test No. 4. No red colour in nickel free alloy.
Tin bronze.	Reacts vigorously blue green solution.	—do—	—do—	
Aluminium bronze.	Reacts vigorously blue green solution.	—do—	White precipitate blue solution.	—
Copper	Reacts vigorously blue green solution.	—do—	Dark blue	—

Aluminium	Soluble	White precipitate.	
Magnesium alloys.	Soluble	Colourless.	
Lead	–do–	–do–	Test No. 5 precipitated.
Lead-silver alloy.	–do–	–do–	Test No. 5. No. precipitation in absence of tin.
Lead-tin alloy.	–do–	–do–	Test No. 5. Black deposit with white precipitation.

SPOT TEST PROCEDURE

Test 1–Nitric Acid Test

Place 1 or 2 drops of conc. nitric acid on a clean metal surface. Observe any reaction for 1-2 minutes. Then dilute with 3-4 drops water and observe the reaction. If solution turns green or blue, use it for iron nail test.

Test 2–Iron Nail Test

Rub a clean iron nail in the coloured acid solution in contact with the specimen. If the alloy contains copper it will be deposited on the nail.

Test 3–Ammonia Test

Dissolve a bit of the metal in nitric acid or attach the surface with a few drops of acid. Dilute somewhat carefully, add ammonium hydroxide to the solution until the solution is strongly alkaline. If copper or nickel is present, a pale blue precipitate will form which on further addition of the ammonium hydroxide becomes a dark blue solution.

Test 4–for Nickel (Paper Test)

Put one drop of acid mixture of 10 c.c. sulphuric acid, 10 c.c. nitric acid 10 grams citric acid and 25 c.c. water, on the metal for 15 to 30 secs. Then absorb the drop on a paper test strip. (The test paper is made out of filter paper dipped in a solution of 10 gms. citric acid, 25 c.c. water, 10 c.c. of 1 % dimethylglyoxime in isopropanol and dried). When potassium hydroxide is dropped on this paper, a red colour will form if the nickel is present. There is no colour interference from iron or other elements.

Test 5—Silver Nitrate Test for Tin

Treat the clean metal surface with a few drops of 2.5 per cent silver nitrate solution. If tin is present, a black deposit with white precipitation will form.

2—COLLECTION, SEGREGATION AND METALLURGY

Problems of Collection and Grading

We know very well that much of India's requirements have to be met by imports from other countries and it is, therefore, of paramount importance that every ounce of scrap should be carefully conserved, collected and graded and then reclaimed for further use.

The following table shows the import figures for brass in various forms during the year 1960.

INDIA'S IMPORT OF BRASS DURING 1960*

Description.	*Quantity* Tons.	*Cwt.*	*Value (Rs.)*
Brass rods	942	6	30,93,286
Brass scrap	3,010	7	73,40,026
Brass sheets and strips	479	2	22,09,193
Brass tubes and pipes	1,392	3	72,88,256
Brass wires	282	1	10,97,385
Brass other wts.	106	4	4,39,735

---

* Annual Number: The Eastern Metals Review, 6th Feb. 1961.

For this reason it is absolutely essential for the secondary metal industry to form an association of scrap dealers who can be initiated into the art and science of segregating and grading of scrap. Technical advice can be given to this association by customers who buy the scrap for processing and the chamber of commerce or the State Director of Industries must advice the scrap producers to sell their scrap only to members of such recognised associations.

The first problem then is that of the producer of scrap. On how well he can reclaim and segregate his scrap depends the whole future of the secondary metal industry. Indian management has been lacking a great deal in the general cleanliness of their plants. *Cleanliness is the first condition in the proper segregation of the scrap.*

Enough floor space should be provided in the factory for storing and proper accounting of all the scrap should be aimed at. The scrap should be segregated daily and a quick market should be found for the scrap so as to avoid storing large quantities. The management should take an active interest to seeing that the scrap is kept segregated.

Segregation should as far as possible be done right at the source of scrap producing unit. Separate containers with large markings should be provided in the machine shop etc. and the workers should be instructed to put their scrap only in particular containers.

II. MANUFACTURE OF STANDARD ALLOYS

THE manufacture of standard alloys from scrap is the most important function of the secondary metal industry. Very often scrap has to be cleaned. Iron and steel pieces can be removed by an electromagnet placed under a moving belt over which the scrap is spread. Oil can be removed from borings, turnings etc. by using an inclined revolving furnace with a gas flame. The oil burns off, leaving clean scrap. This can be directly charged in a melting furnace. In many cases it becomes necessary to shape the scrap for furnace use by shearing, baling etc.

The final success of the operation depends on the melting practice and control of operations.

SECONDARY BRASS AND BRONZE

Metallurgy

In general, in the manufacture of these alloys, the secondary metal is first sorted, melted and cast separately. These casts are then analysed; a charge for a standard alloy is then calculated and weighed amounts of the various grades are then melted in a suitable furnace. Air is blown through the melted charge to rid the metal of detrimental impurities or reduce them to specification limits after which they are skimmed off with the aid of the flux. The bath of metal is poled with wood, chemically tested before and after any additions are made to bring it up to specification and finally poured into ingots or castings, after which a final chemical and physical examination is made. The physical properties of the final product will depend on several factors like :

1. Pouring temperature
2. Melting practice
3. Pattern equipment
4. Sand conditions
5. Gates and risers.

Selection of fluxes to be used in melting brass scrap

It was found by experimentation that the spelter loss in melting brass scrap was least (about 1 %) when glass with a little wood charcoal was used as flux. The loss with borax as a flux was about 3 %, with common salt about 5%, with charcoal about 3%, and with charcoal and borax about 2 %. Glass is an excellent flux for the reason that it does not become liquid at the temperature of the melted brass and therefore, does not attack the crucible.

It becomes pasty and covers the metal and is readily skimmed off, a different operation with a liquid flux. The cheapness of the glass and the fact that crucibles are not attacked should render its use attractive though the majority of brass smelters seem to be ignorant of this fact.

Flux is used when the metal has melted down in the proportion of 1/2 to 1 % of the metal and then stirred for five minutes and scum removed. The following flux mixture is most suitable for brass to be used for electrical purposes :

Salt	5 parts	
Silica	15 parts	
Coal dust	5 parts	(not very fine otherwise it flies off; pea size should be used)

In refining the red brass scrap the following mixture has been found useful :

Powder glass	8 parts
Calcined borax	1 part
Charcoal	2 parts

Quantities to be used is again 1/2—1 % of the charge as is used in the above case.

Instead of simple slagging materials used in industry special fluxes should be used. These consist of the mixtures of borax, sodium chloride, ammonium chloride and manganese dioxide. The advantage of adding manganese dioxide along with ammonium chloride is to remove any iron which may be present in the melt.

For bell metal and high grade bronzes of gun metal, the flux used is as follows :

Soda ash	1 part
Borax	0.25 parts
Yellow prussiate of soda	1 part

This is used 1 % of the charge, and charcoal covering is used all along the melt. The tone of the bell and clinkering sound of the bronzes is improved by using this flux.

Degassing: For degassing, chlorine or nitrogen is introduced into the molten alloy. This removes any harmful dissolved gases which may give rise to blow holes etc. The gas is conducting into the molten metal by passing it through *silica or carbon tubes* perforated at the end on sides. The tube reaches almost to the bottom of the pot. Gas bubbles up through the metal and may be passed for 5 to 10 minutes per 100 lbs. of the metal. The temperature of the metal is usually 650° to 730°C.

Antimony can be removed or lowered in an alloy by means of aluminium. Aluminium foils are well shaken in the molten bath at a temperature of 650°C. and kept for sometime well mixed. The metal is cast in a thin stream. This is melted again in cast iron pots and the remaining aluminium is removed by steaming or by ammonium chloride at a temperature of 600° to 650°C.

SELECTION OF FURNACES FOR MELTING BRASS SCRAP ON A SMALL MANUFACTURING SCALE

Crucible Furnaces

These are good when small melts of suitable composition are to be made. The old type of pit furnaces have many metallurgical disadvantages compared with the more recent types of coke fired furnaces, they are relatively uneconomical as their capacities are very limited; also the life of the crucible is shortened by mechanical abrasion of the fuel, local overheating, sudden cooling of the exterior by cold charges of the fuel etc. The superseding of the old type of natural draught coke fired lift out furnace by forced draught pit type giving improved efficiency and quicker melting, is but one of the recent developments in crucible furnace design and can easily be suited to this industry.

(ii) Oil or gas firing on the other hand gives more uniform heating and the modern form of tilting furnace eliminates the danger of mechanical damage to the pot, and minimise the effect of the temperature changes. The sulphur content of the gas is less than that of coke and the risk of contamination by this metal is proportionately lower.

The loss of zinc on melting brass in such crucible furnace is only 2 % which is quite low.

(iii) Electrical furnaces are likely to replace all other types of furnaces for melting brass and to produce brass suitable for electrical industry. Successful and economical melting can be done only when electricity is available cheaply.

Melting Practice

First the crude cleaned foundry scrap is charged and when this has melted down this forms a molten bath into which the small sized materials sinks down and melting rapidly takes place without any danger of oxidation or gasification. The metal should be covered with a layer of flux and charcoal.

The factors in melting of economic concern are: to melt as speedily as possible with the minimum fuel consumption and metal loss, while those of technical and metallurgical interest are concerned with maintaining conditions of melting which will not lead to the quality of the metal being impaired. In short to ensure that the metal suffers no contamination from contact with fuels, furnace gases and products of combustion, the refractory material of the crucible or furnace lining or stirring rods, rakes etc. that the molten charge is adequately mixed; and that it is raised to and poured at the appropriate casting temperature.

The next operation, after brass scrap melting and adjusting the composition to requirements by suitable additions is casting of brass into suitable mould to get sound ingots. In this respect, water-cooled moulds of the Otto-Junker's and Erichsen's type have marked decisive stage of progress in the production of sound ingots.

Most important amongst the advantages of the water-cooled moulds is the possibility of obtaining uniform temperature throughout period of solidification. The older types of cast iron moulds used to deteriorate after about three weeks' and now the water cooled moulds are used for continuous service for more than 18 months each. After the cast billet has solidified it is stripped, that is, the mould is opened and the billet is taken out and this is sent to the rolling section.

Precautions

(i) The moulds into which the metal is poured should be pre-heated.

(ii) The moulds should be dressed with some dressing material.*

III. BRASS ROLLING-FACTORY LAY-OUT

At most of the centres the industry is in flourishing condition and much larger quantities of the brass sheets are imported for local use. The consumption of brass sheets in the whole province is about 2,25,000 mds. per annum nearly. There are no large scale rolling mills for manufacturing brass sheets except a few small rolling mills for manufacturing sheets at Hathras, Moradabad, Mirzapur, Shamli and Hapur. There is not a single good press plant for pressing brass sheets for which a great necessity is felt at various places.

From the survey of the brass industry of the State and considering the demand of the brass sheets and pressed utensils, it is clear that a large scale rolling mill should be installed at one central place, so as to supply sheets to the whole of the State. Small units of die pressings of brass should be installed at Hathras, Moradabad, Kanpur, Farrukhabad, Mirzapur and Varanasi to press different articles into various shapes according to the tastes and local requirements.

---

* Refer Fesco Preparations Manufactured by Messrs. Foundry Services Ltd., Birmingham.

From all considerations a scheme of establishing a large rolling mill for the production of sheets and establishing press plants at various places is given.

PROPOSITION OF SITE

The first consideration after deciding to start the industry is the location of the factory. Various factors are to be considered in locating the suitable site. The place chosen must be such as can provide facilities of transport, power and technical labour etc. For the location of the rolling mill the following factors are to be considered :

(a) The necessary scrap, fuel and power are abundantly and cheaply available.
(b) It is provided with adequate rail and road facilities for the transit of the raw materials and finished products.
(c) It gets an adequate supply of suitable labour.
(d) It has a good market nearby.

3769

From all considerations, Kanpur is considered to be a suitable place. It occupies a central position in the State. It is provided with great transport facilities. Electric power is the cheapest in the whole of the State. A suitable type of labour is available. The labour in Kanpur is a little more costly but it is more efficient. Being the centre of the province, the scrap material from all sides can be easily brought even if the scrap has to be imported from Calcutta and Bombay. Therefore, a plant for proposed brass industry may be installed at Kanpur.

DETAILS OF THE MAIN ITEMS OF EXPENDITURE*

(*a*) LAND REQUIREMENTS

Land required as the working space for the machines-
60 ft. × 180 ft.=10,800 sq. ft.

---

* Mr. A. R. Kapoor, B.Sc. (Met.) thesis, B.H.U., 1949.

Land required for the office=50 ft. × 20 ft.=1000 sq. ft.

Total=10800 + 1000=11,800 sq. ft.

Cost of land at Kanpur=Rs. 30|- per sq. ft.

∴ Cost=11,800 × 30=Rs. 3,54,000

Expenses in raising shades with foundation and flooring ..	Rs.	94,400
Total expenditure in land and shares	Rs.	4,48,000

(*b*) COST OF MACHINERY (MECHANICAL)

The cost of different machines required for the proposed industry is given in the following :

(i) *Foundry and Rolling Mill Equipment*

Furnace Plant

(*i*) Two low frequency induction furnaces arranged for A.C. each of 6 cwt. capacity. ..	Rs.	100,000
(a) Lining material for it and to be kept in reserve (to last for half a year). ..	Rs.	20,000
(b) One spare coil for item No. 1.	Rs.	5,000
(*ii*) One exhaust pipe-hoods and Exhauster.	Rs.	8,000
(*iii*) Two double type plate moulds including hoses for plates of 30″ × 24″ × 3″. ..	Rs.	20,000
(*iv*) Two mould cars for item No. 3.	Rs.	7,000
Total ..	Rs.	1,60,000

(ii) *Auxiliary Equipment*

1	stationary Magnet drum separator ..	Rs. 3,000
2	scrap bundling machine ..	Rs. 10,000
1	Cylindrical grinder	Rs. 4,000
1	Wilfley Table	Rs. 3,000
1	Plate moulding machine	Rs. 30,000
1	Weighing machine with moveable jockey for 300 Kilograms and a small weighing machine for 26 Kgms. ..	Rs. 2,000
	Total ..	Rs. 52,000

Total cost .. Rs. 1,60,000 + Rs. 52,000
.. Rs. 2,12,000

(iii) *Rolling Mill Equipment*

To roll about 15 tons of blooms into sheets of various gauges in 24 hours, the following equipment would be required as per quotations received from "Alfred Herbert (India) Ltd."

The following mill consists of a 24″ high hot rolling stand with rolls 24″ diameter × 50″ body length and a two high cold roll stand with rolls 24″ diameter × 50″ body length.

These two roll stands will be driven by a 250 H.P., 750 R.P.M. joint driving motor, the motor speed being reduced to the requisite mill speed of 32 R.P.M. through a high efficiency helical speed reduction gear. The two rolls of the hot roll stand will be positively driven and for this reason a pinion housing is arranged between the high efficiency helical speed reduction gear and the hot roll stand. With the cold roll stand only the bottom roll will be positively driven; the top roll will be kept in motion by means of a friction gear drive.

The hot roll stand is fitted with a tilting table of ingoing side and a lifting over table at the out-going side.

The latter table serves for lifting the stock over the top roll so that it can again be fed between the rolls at the ingoing side. The cold roll stand will be fitted with one lifting over table at the out-going side.

The lumpsum price of the rolling mill plant consisting of high efficiency helical speed reduction gear, coupling, pinion housing, 2 high hot roll stand with tilting table and lifting over table, bed plates, coupling spindles and friction gear drive, guillotine shear and circular shear amounts to Rs. 7,00,000 nearly.

In addition to the above cover plates one 5-ton crane reheating and annealing furnaces and pickling department will cost Rs. 2,50,000.

Therefore the total cost .. Rs. 7,00,000 + Rs. 2,50,000
.. Rs. 9,50,000

(*iv*) *Electrical Equipment*

The following electric motors will be required :

One 250 H.P., 720 R.P.M. drive motor.

Two 3 H.P. 1000 R.P.M. motors for oil pumps.

One 20 H.P. 750 R.P.M. for the electric screw down of the top roll of the 2 high hot roll stands.

One 20 H.P., 750 R.P.M. motor for the lifting of the tables of 2 high hot roll stands.

One 15 H.P., 750 R.P.M. Motor for the lifting over table of cold roll stands.

One 6 H.P. 750 R.P.M. motor for the shear.

One 5 H.P. 750 R.P.M. motor for the circular shear.

Complete electric equipment for foundry and rolling mill plant as well as sub-station cable lines, and the lightning plant will cost Rs. 4,00,000.

Thus the total cost of Rolling Mill equipment and Electrical equipment comes to Rs. 13,50,000.

Total cost of the plant

1.	Mechanical and Electrical equipment ..	Rs. 13,50,000
2.	Insurance and freight charges ..	Rs. 2,00,000
3.	Custom duty, clearing charges, Inland railway freight etc.	Rs. 2,00,000
4.	Cost of erection and land foundation etc.	Rs. 4,48,000
	Total ..	Rs. 21,98,000
	Working Capital	Rs. 4,00,000
	Grand total ..	Rs. 25,98,000

Calculation of the Cost

In calculating the cost of production of brass sheets, the main factors to be considered are :

- (i) Cost of raw material
- (ii) Cost of power
- (iii) Repairs and maintenance
- (iv) Labour
- (v) Over-head charges :
  - (a) Depreciation and interest
  - (b) Management in general
  - (c) Miscellaneous including taxes, advertisement and office expenses

(*i*) *Raw Materials* : required are brass scrap, fluxes, power water, fuel and coke. Scrap is the chief item and forms the largest part of the cost. The price of brass scrap varies and depends upon quality. The fluxes required will be about 6 lbs. of charcoal and 2 to 3 lbs. of a mixture of salt and borax per ton of scrap melted. The cost of these would be annas 12 per ton of sheets. The price of coal varies from Rs. 35 to Rs. 40 per ton.

For pickling one ton of brass sheet about $3\frac{1}{2}$ gallons of sulphuric acid are required. The cost of the same may be taken as Rs. 7.50 nearly.

(*ii*) *Electric Power* :

(a) *Power required for foundry* : Assuming 250 K.W.H. per ton of blooms produced, the power required for 15 tons will be—250 × 15=3,750 K.W.H.

Therefore, K.W. input of the furnaces$=\frac{3754}{24}=156$

Power factor=.77

Therefore, K.V.A. input$=\frac{156}{\cdot 77}=202.6$

Load factor approximately=0.8

Units for 24 hours=156 × 24 × ·8=3,000 approx.

Taking 25 days of work in a month, the units required for a month=3,000 × 25=75,000.

(b) *Power for rolling mill* :

Total H.P. of the Motor = 325
Efficiency of the Motor = 89 %
Therefore, K.W. input = $\frac{325 \times .746}{.89}$
= 272.4
Power factor .. .. = 89
K.V.A. input .. .. = $\frac{325 \times .746}{.89 \times .89}$
= 306

Units per month assuming 25 working days, will be 272.4 × 24 × 25 × .9 = 147100.

Total power for foundry and rolling mill :

K.V.A. Demand = 202 + 306 = 508, say 510
Units per month = 75,000 + 1,50,000
= 2,25,000

Taking into account the power required for crane, repair shop, lighting purposes and other accessories, the figures would be as follows :

Maximum demand = 550 K.V.A.
Units per month = 2,50,000 K.W.H.

In rolling brass sheets 50 % of the material rolled is rejected due to stickings and other rolling defects and is returned to the foundry for remelting. If 15 tons of blooms are rolled per day, the out-turn of the sheets will be about 10 tons. Taking 25 days in a month, the total out-turn will be 250 tons. Hence power required per ton of the sheets comes to about 1000 units.

Cost of Supply

The cost of power required for the above installation at Kanpur is about 15 nP. per unit taking into consideration all charges (tariff etc.). Thus the cost of power per ton of sheets (1000 units) = Rs. 150 nearly.

Labour

Labour at industrial town is costlier but more efficient at places remote from industrial centres. For economic working maximum use of automatic appliances should be used. Skilled labour is essential for the efficient working of the plant. The cost of labour including wages and bonus at the centres like Kanpur would be about Rs. 150 per ton of sheets and circles.

Over-head charges

The over-head items (interest, taxes, depreciation of buildings and equipments etc.) are of great importance for an industry and should be kept at a minimum. The Plant should be run continuously. In order to keep these over-head charges down to minimum the plant should be run continuously at a maximum capacity of economic working. Depreciation on Rs. 26,00,000, the total cost of buildings and equipments at the rate of 10 %

=Rs. 2,60,000 per year. Working 300 days per year and 10 tons per day, the total output will be 3000 tons. Hence, the charges for depreciation per ton of sheets will be Rs. 86; interest on the sum at the rate of 6 % will be about Rs. 50 per ton of sheets. The cost per ton of brass sheets may be calculated at a particular centre, say at Kanpur.

1 ton of brass scrap (including freight and handling charges)	Rs. 2,700
Metal Loss 1 % (Zinc)	20
Fluxes, charcoal, borax and salt-1.25 tons of coal	40
3 gallons of sulphuric acid	10
Cost of lining per ton of sheets ..	6
Repairs and maintenance	10
Labour	150
Water	12
Power 1000 units @ 7 annas per unit ..	150
Depreciation	86
Interest	50
Management in general	30
Miscellaneous	20
Grand total ..	Rs. 3,284

Depending upon the cost of scrap and electricity power the cost of production of brass sheets per ton will vary from Rs. 3,200 to Rs. 3,500 at different centres of Uttar Pradesh. The present price per ton comes to Rs. 4,500 per ton of sheets. Thus a clear profit of Rs. 1,300 or say Rs. 1,000 per ton of brass sheets is obvious.

Press Plant

Sheets vessels are becoming increasingly more popular as they are light, plain and better-finished. Large quantities of pressed utensils are being imported into the State where they find a ready market. It has been suggested that position of the brass industry requires small units of press plants to be installed at various centres according to local tastes and requirements. The lay-out and the equipment of each plant at each centre will be determined by the types of the materials to be produced, and the sizes and quality of the product. For an out-turn of about 4 cwt. of finished thalies daily, the following equipment will be required :

(i) Electric Press costing Rs. 20,000 nearly
(ii) Dies and punches according to the size of the articles about Rs. 2,000
(iii) A rolling machine cost Rs. 4,000 for rolling thalies to the exact shapes
(iv) A turn machine Rs. 1,000 for turning the thalies
(v) A polishing machine costing Rs. 1,000
(vi) Turning apparatus if turning is required Rs. 200
(vii) An electric motor for driving the machinery costing Rs. 1,400

The total cost of the plant comes to Rs. 29,600 nearly

Operation of the plant

For an out-turn of 1,000 thalies to be pressed *out of cut ready to the size of* 14″ *to* 16″, the working is as follows :

A workman will take about 2 days to press 1,000 circles. Then these thalies are rolled for shapes. A workman will take about 4 days for exact shaping. Subsequent to shaping a workman will take nearly 3 days to turn 1,000 thalies on the turn machine. Lastly, the articles are to be polished for which a good hand will take 4 days.

The proper site for establishing press plants are Moradabad, Hathras, Kanpur, Farrukhabad, Varanasi and Mirzapur.

PART B

METALLURGICAL STUDY

CHAPTER III

CHEMICAL ANALYSIS

THE typical samples of brass were taken and their analyses were carried out in the laboratory of the College.

Principle

Dissolved 1 gram of the alloy in 10 c.c. con. nitric acid and 10 c.c. water. Evaporated to about 10 c.c. Redissolved in 20 c.c. dil. nitric acid Filtered off SnO_2, through the pulp filter. To the filtrate added 10 c.c. conc. Sulphric acid and evaporated to fumes. Redissolved in 60 c.c. water. The precipitate was settled. Filtered off the lead sulphate through the gooch crucible with asbestos. Ignited and weighed as SnO_2. Temperature of ignition was 500°C.

Into the filtrate from $PbSO_4$, passed H_2S to precipitate copper as copper sulphide and determined copper by any of the two methods :

(a) *Iodide Method*

When potassium iodide is added to a solution of copper sulphate in water, iodine is liberated. By titrating the liberated iodine against a standard solution of sodium thio-sulphate, using freshly prepared starch solution as an indicator, the amount of copper can be determined. The reactions that take place are represented by the following equations :

$$2\,CuSO_4+4\ KI = 2\ CuI+2\ K_2SO_4+I_2 \quad .. \quad (1)$$

$$2\,Na_2S_2O_3+I_2 = 2\ NaI+Na_2S_4O_6 \quad .. \quad (2)$$

From equation (1) it is clear that 1 gram, atom of free iodine corresponds to 1 gram-atom of copper.

(b) *Copper by Electrolysis**

When a current of electricity is passed through a solution of copper sulphate or copper nitrate, metallic copper is deposited on the cathode. The material of which the electrodes are made is platinum, as this is unaffected by the acidity of the bath that is being electrolyzed.

To the filtrate, ammonia and ammonium chloride added and boiled for 10 minutes. $Fe(OH)_3$ is precipitated out. Ignited and weighed for Fe_2O_3. From the filtrate the zinc is determined as pyrophosphate.

The following is the analysis of some typical samples of brass :

Table I

TOM ROLLED PIECE FROM KEDAR ENGINEERING WORKS, MORADABAD

No.	Cu	Zn	Fe	Pb	Sn	Inference
1.	50.5	44.1	4.68	.6	.1	.. Due to high percentage of iron and low percentage of copper in brass, it has cracked while rolling.
2.	52.01	43.2	4.06	.62	.1	..
3.	53.2	42.7	3.30	.7	.01	..

Table II

SAMPLE OF LOTA FROM BANARAS-SUNDARPUR VILLAGE

No.	Cu	Zn	Fe	Pb	Sn	Inference
1.	60.8	37.7	1.1	.38	..	Iron and lead impurities are always associated with the scrap and hence its identification is necessary before melting.
2.	61.2	36.7	1.6	.47	..	
3.	62.3	35.08	2.1	.5	..	

---

* The author has designed and constructed an apparatus for determining the percentage of copper and brass electrolytically. Two views of this apparatus are shown in Figs. 5 and 6.

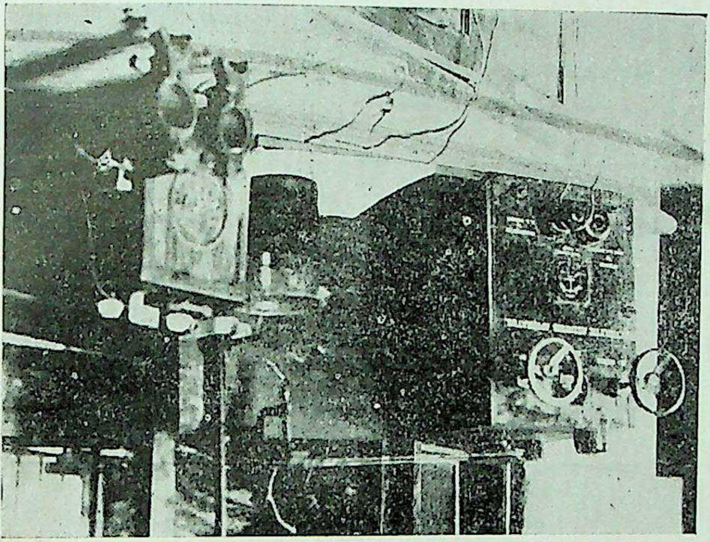
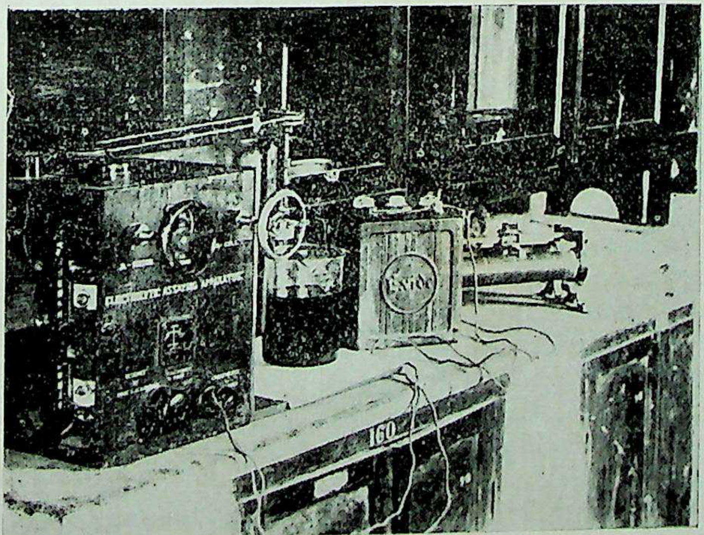


Fig. 5



ELECTROLYTIC ASSAYING APPARATUS
Exide
160

Fig. 6

Table III

ROLLED AND FABRICATED ARTICLES FROM IMPORTED SHEETS

No.	Cu	Zn	Fe	Pb		Inference
1.	62.3	37.30	.18	.2	..	Impurities are negligible and
2.	62.4	37.22	.15	.21	..	have no effect on rolling as
3.	61.7	37.94	.11	.23	..	the % of iron is low

Table IV

ANALYSIS OF A TEA SET (CAST) SAMPLE, MORADABAD

No.	Cu	Zn	Fe	Pb	Sn		Inference
1.	58.2	37.29	4.2	.2	.09	..	Impurities are always
2.	59.3	37.65	2.8	.15	.10	..	associated with the
3.	60.1	36.52	3.1	.17	.11	..	brass scrap.
4.	60.8	36.12	2.7	.23	.11		

Lead-Tin Alloys

Chemical Analysis

The representative samples of solders of tinning alloys used in the brass industry were taken and were analysed in the Chemical Laboratory to interpret their properties.

Principle

Tin : The alloy is dissolved in concentrated hot hydrochloric acid with the aid of potassium chlorate when $PbCl_2$ and $SnCl_4$ are formed. On cooling and dilution with distilled water, $PbCl_2$ separates. This is filtered off. From the filtrate tin is determined. Principle underlying is this that stannic chloride is reduced to stannous chloride when boiled with HCl and powdered antimony. The cold reduced solution of $SnCl_2$ is titrated with a standard solution of iodine.

$$SnCl_2 + I_2 + 2\ HCl = SnCl_4 + 2\ HI$$

Lead and Antimony

The drillings of the alloy are heated in Kjeldahl flask with concentrated sulphuric acid; sulphates of lead, tin or antimony, if present are formed. The lead sulphate is filtered off through gooch crucible, ignited and weighed. The filtrate contains $Sb_2(SO_4)_3$. On the addition of standard $KMnO_4$ solution the antimonious sulphate is oxidised to antimonic acid and thus the value of the standard $KMnO_4$ used is a measure of the amount of Sb present.

TABLE V

TINNING ALLOY—'A' GRADE

No.	Pb	Sn	Sb		Inference
1.	63.1	34.58	2.3	..	*Tinning alloy contains very low proportions of tin in the alloy.
2.	62.7	35.18	2.1	..	
3.	62.8	34.9	2.3	..	

TABLE VI

SOFT SOLDER—'B' GRADE

No.	Pb	Sn	Sb		Inference
1.	72.1	27.68	.21	..	Low grade soft solders very common in Industry.
2.	72.8	26.96	.24	..	
3.	72.9	26.80	.30		

II. MICROSCOPIC EXAMINATION

For microscopic examination, samples were selected from various sources in Moradabad and Varanasi. They were filed, made smooth by emery papers and finally polished by Brasso on a flannel cloth. There was a bit of difficulty experienced in polishing the samples and took a lot of time. However, by careful polishing this difficulty was minimised. The specimens were etched in acid ferric chloride solution :

---

* In place of pure tin which was used previously for tinning the articles, a cheap alloy of lead and tin is used and is the chief cause for the deterioration in the quality of the tinning.

Ferric Chloride	10 grams.
Hydrochloric Acid Conc. ..	6 c.c.
Water	100 c.c.

and examined under Reichert Microscope and their photographs were taken. The microphotographs with their descriptions are given in the succeeding pages.

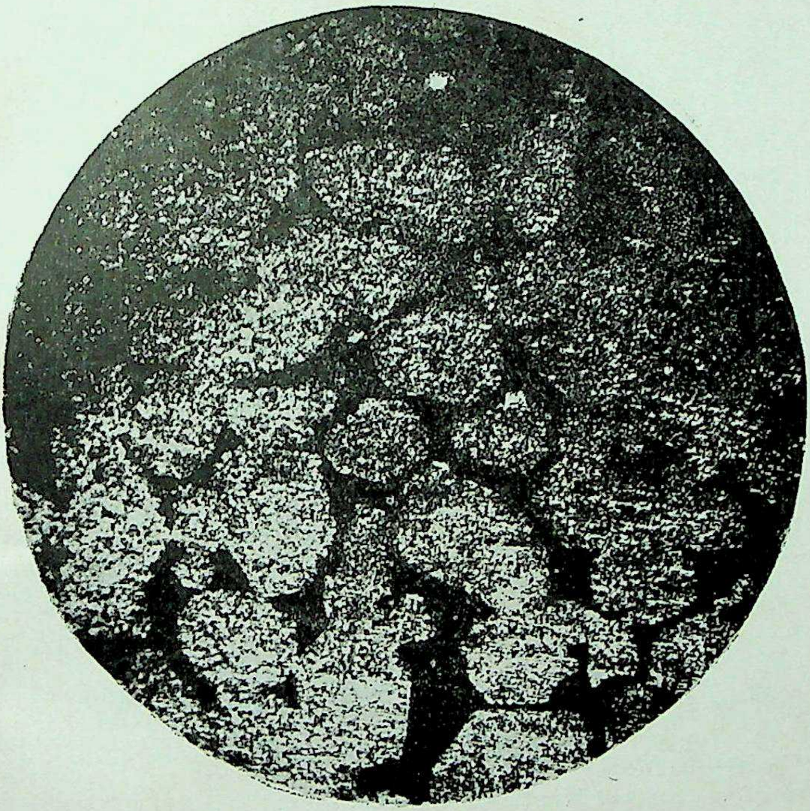


Fig. 7

Composition: 50.5% Cu, 44.1% Zn, 4.68% Fe, 0.6% Pb, 0.1% Si.

Sample : Torn rolled piece from Kedar Engineering Works, Moradabad.

Etching reagent : Acid ferric chloride solution.

Time : Half a minute.

Magnification : 225

Description : Due to high % of zinc and considerable proportion of impurities gama constituent has developed, which has induced brittleness. So while rolling, it has given way and constituent can be seen under microscope which is *bluish*.

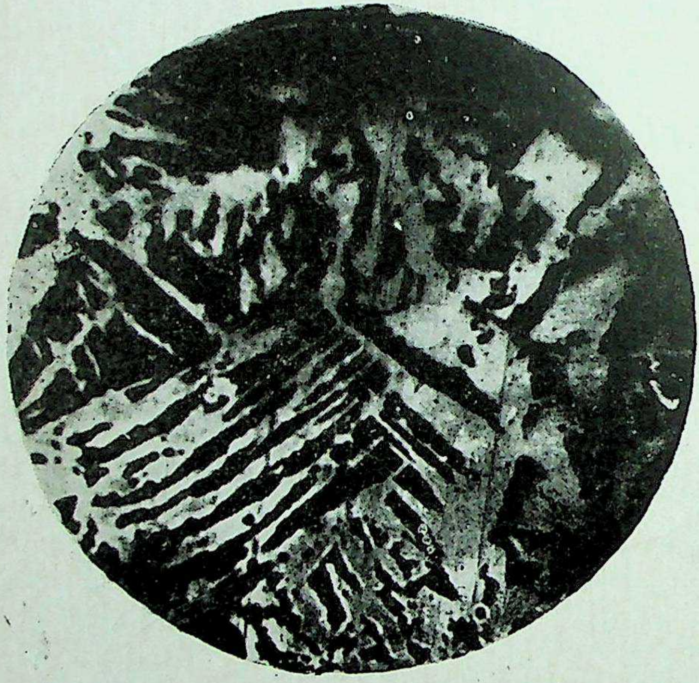


Fig. 8

Composition : 60.8% Cu, 37.7% Zinc, 1.1% Fe, .38% Pb.

Sample : Cast 'Lota' from Sunderpur village.

Etching reagent : Acid ferric chloride solution.

Time : 25 Secs.

Magnification : 225.

Description : Constituents of α and β solid solutions, α Light and β dark. The structure is coarse one and contains some impurities also.

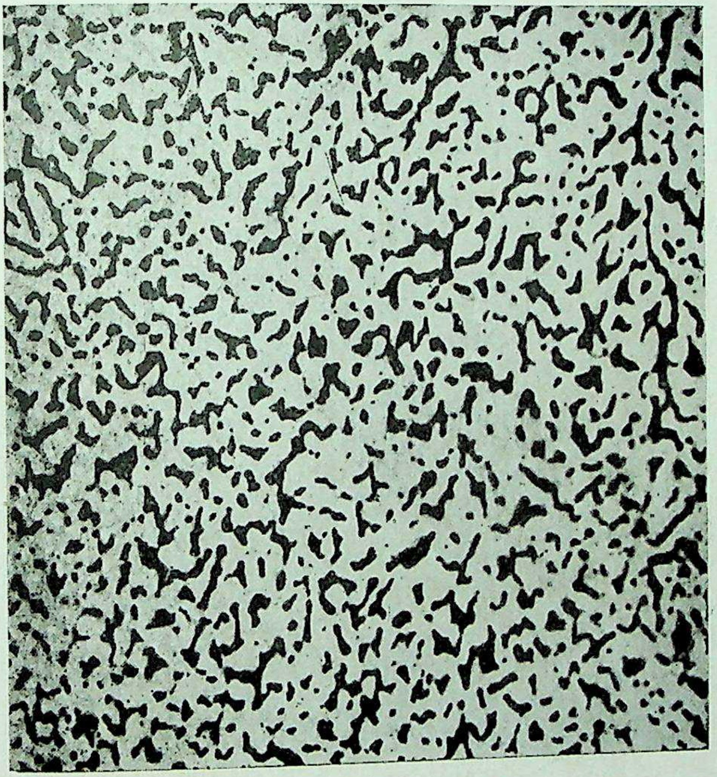


Fig. 9

Composition : 62.3% Cu, 37.3% Zn, .18% Fe, .25% Pb.

Sample : Imported foreign sheets.

Etching reagent : Acid ferric chloride solution.

Time : 25 Secs.

Magnification : 225.

Description : Transverse section showing uniform structure of α and β solid solutions. Hot rolled.

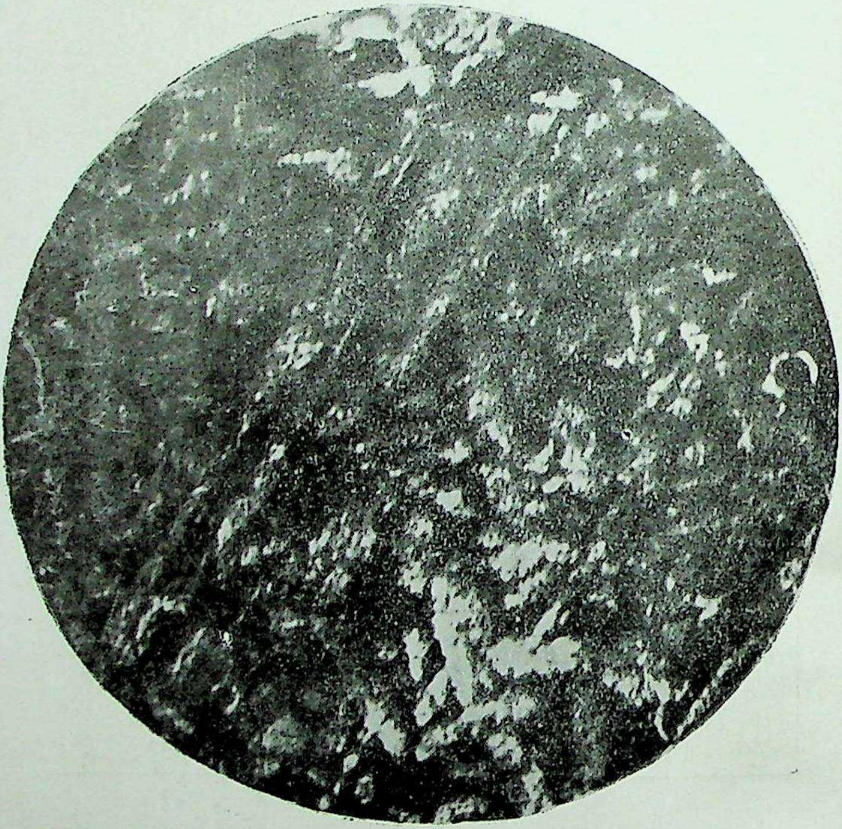


Fig. 10

Composition : 58.2% Cu, 37.2% Zn, 4.2% Fe, .2% Pb, .09% Sn.

Sample : Tea set cast sample, Moradabad.

Etching reagent : Acid ferric chloride solution.

Time : 25 Secs.

Magnification : 225.

Description :.. α and β are clearly represented. α is white and β is dark. Cast impurities are always associated with scrap.

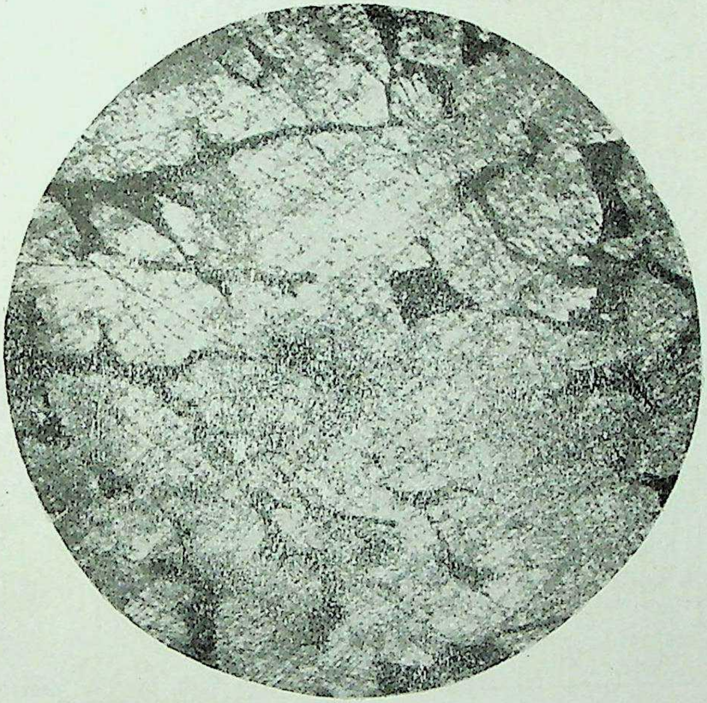


Fig. 11

Composition : 60% Cu, 39% Zn, .3% Fe, Ni 0.2%.

Sample : Cast brass sample from the pit furnace, Sheet Engg. Works, Moradabad.

Etching reagent : Acid ferric chloride solution.

Time : 25 Secs.

Magnification : 225.

Description : α and β brass and worth noting the effect of impurities on the α and β brass.

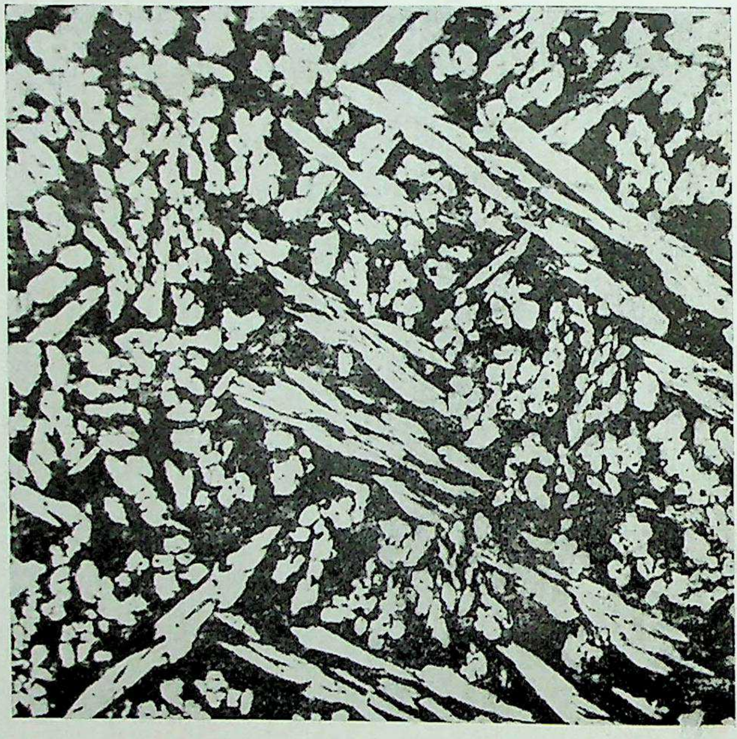


Fig. 12

**Composition* : Approx. 60/40 brass.

Sample : Brass prepared from pure metals in the College laboratory.

Etching Reagent : Acid $FeCl_3$ solution.

Time : 25 Secs.

Magnification : 150.

Description : Consisting of α and β solid solution, α light and β dark. No impurities present in the alloy. A typical and cast structure.

* Electrolytic copper and A. Z. Mark Zinc was used.

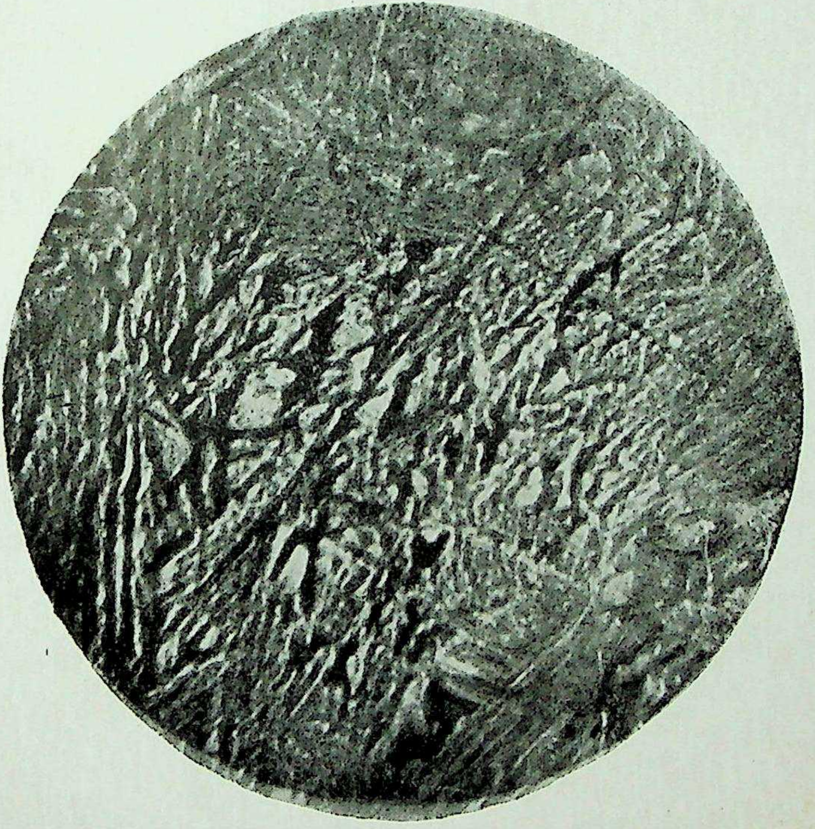


Fig. 13

**Composition* : Approx 60/40 brass.

Sample : Brass prepared from pure metals in wind furnace.

Etching Reagent : Acid $FeCl_3$ solution.

Time : 25 Secs.

Magnification : 150.

Description : Muntz metal, cast shows α and β separate along crystallographic axis. No impurities are present.

---

*Flux used—NH_4 Cl and borax.

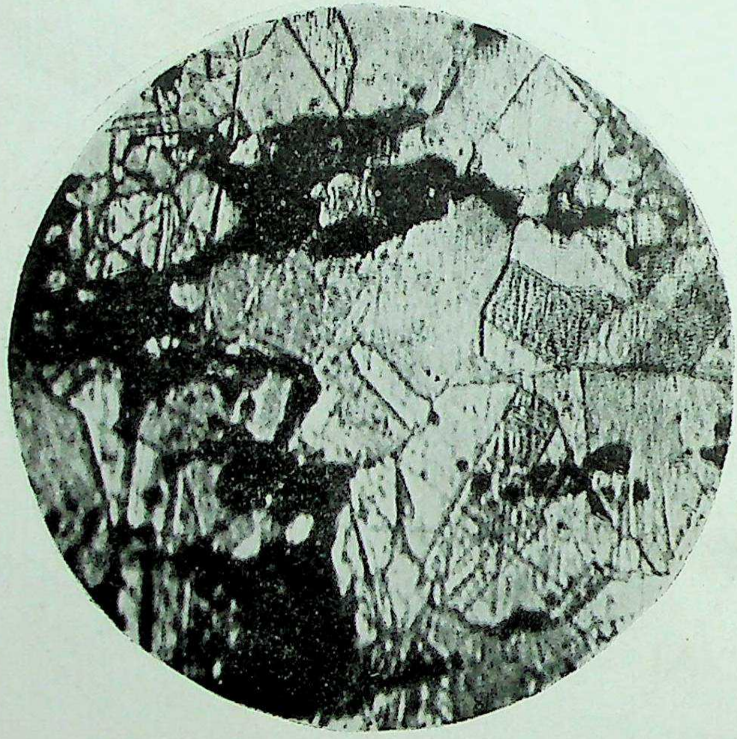


Fig. 14

Composition : 70/30 brass.

Sample : Cartridge case used as raw material in the industry.

Etching Reagent : $FeCl_3$.

Time : 25 Secs.

Magnification : 225.

Description : Cold worked α brass, shows annealing twins and some impurities dark associated with the brass scrap.

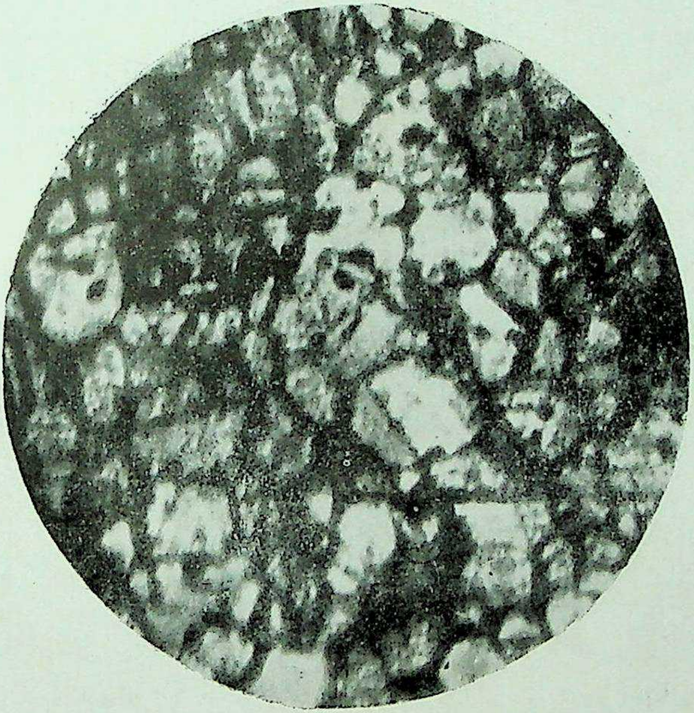


Fig. 15

Composition : Brass 60/40 approximately.

Sample : Rolled brass sheet from H. M. W. Co., Moradabad used for refining.

Etching Reagent : $FeCl_3$ (acid solution).

Time : 25 Secs.

Magnification : 225.

Description : Cold worked, α annealed, α and β and twins.

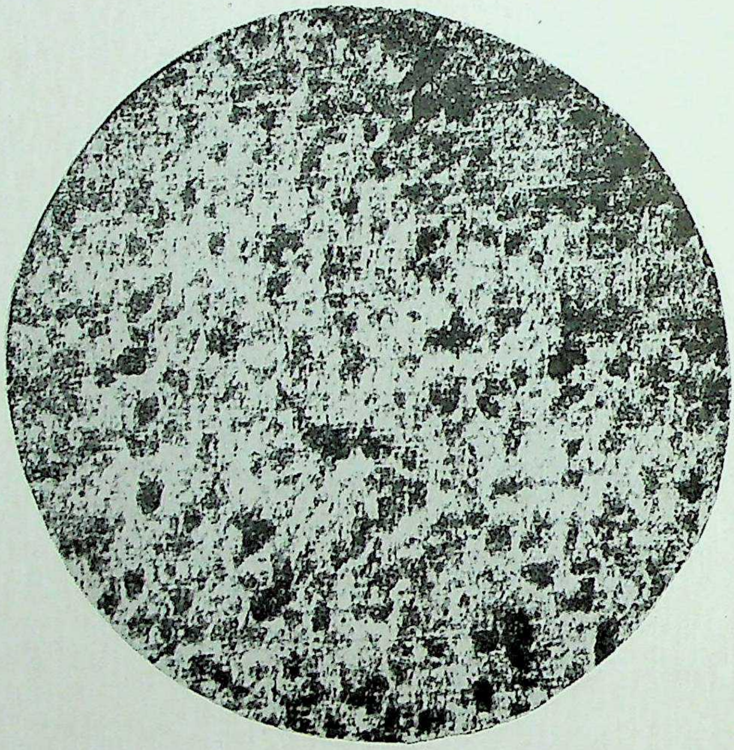


Fig. 16

Composition : Pb – 63%, Sn – 34.58%, Sb – 2.3%.

Sample : Tinning alloy.

Etching Reagent : Acid ferric chloride solution.

Time : half a minute.

Magnification : 225.

**Description* : Black crystals of Pb globules surrounded by eutectic of Pb and Sn in the matrix.

---

*A cheap alloy of Pb and Sn–containing higher % of Pb is used for tinning.

CHAPTER IV

TINNING COPPER AND BRASS

BY IMMERSION IN A COLD BATH :*

THE art of coating metals with tin by means of the wiping process is of considerable antiquity, and it is still the most widely used method of tinning process, but in the last few years there have been considerable advances in the art of depositing tin in a cold bath. In the wiping process the success of the operation depends largely upon the skill of tinners, who rely on their experience and personal skill rather than scientific control. Temperature must be judged entirely by inspection and the work must be carried out quickly. Speed is necessary in order to avoid oxidation of the heated article, before the tin is applied and to prevent undue formation of intermetallic compounds during the wiping.

Some experiments were conducted on tinning on modern lines which are commonly practised in America and other Western countries, in order to investigate how far this can be successfully applied to the metal industry of U.P. The results of these experiments were found quite satisfactory. The coatings obtained in this way on different brass and copper articles were far superior to those obtained by electro-plating in the market. But it was found that the results were inferior to those obtained by hand tinning with A grade alloys.

Advantages of the Process

(i) This process also minimises the labour involved in the finishing of the tinned articles.

---

* Metal Industry, June 28, 1940 by John D. Sullivan and A. E. Pavlish.

(ii) The article which is treated in this way goes through only one stage of surface treatment whereas in tinning the article has to undergo different stages from one place to another and thus, the efficiency of the work is considerably reduced.

(iii) Coatings can be applied to intricate shapes and to a variety of sizes that cannot be readily handed by tinning process.

The details of such a process are given below :

Process

The article is thoroughly cleaned to remove grease and dirt and preferably pickled, although this step is not essential, immersed in a solution consisting essentially of sodium stannite and sodium cyanide, washed and dried. The better the condition of the metal before immersion better will be the appearance of the coating. An outstanding feature of the process is that coating is effected readily *by immersion in a cold bath.* The concentration of the tin in the bath is maintained high enough to avoid stirring of the bath.

Composition

The composition of a few typical baths that have been used for the deposition of tin by the immersion process are :

(i) Saturated solution of cream of Tartar (Potassium acid tartrate) containing 4 to 30 gms. of stannous chloride per litre and operated at boiling temperature.

(ii) A bath containing 20 to 30 gms. of ammonium alum and 1 to 2 gms. of anhydrous stannous chloride per litre. The solution must be used at the boiling temperature.

(iii) An alkaline bath containing 15 gms. of stannous chloride, 18.7 gms. of NaOH and 7.5

gms. of NaCN per litre, operated at boiling temperature.

Character of coating

A uniform adherent coating is obtained (Fig. 17); the thickness depends upon the time of immersion. Data are given in the table for a specific bath containing 50.0 g/l NaCN, 5.0 g/l $SnCl_2$. 2 H_2O which is a photo-micrograph of tin-coated-copper. Copper here is a backing material for the thin tin coating.

RELATIONSHIP OF TIN DEPOSITED ON COPPER TO THE PERIOD OF IMMERSION IN THE BATH*

Period of immersion in the bath	*Tin deposited* Thickness	Wt. g/Dm^2
5 minutes	0.000004	0.006
15 minutes	0.000006	0.012
30 minutes	0.000009	0.017
1 hour	0.000014	0.026
2 hours	0.000021	0.040
24 hours	0.00014	0.0262

Heating the coatings

If a tin-coated article is heated slightly above the melting point of tin the latter alloys at least in part with the copper. This is shown in fig. 18. This surface may be given an additional immersion treatment so that there are three distinct layers.

1. Tin.
2. Diffused layer of tin and copper.
3. Copper (see Fig. 19).

Chemical consideration of the process

The process is essentially one of chemical replacement at ordinary temperatures. It is merely stoichio-

---

* Metal Industry, June 28, 1940.

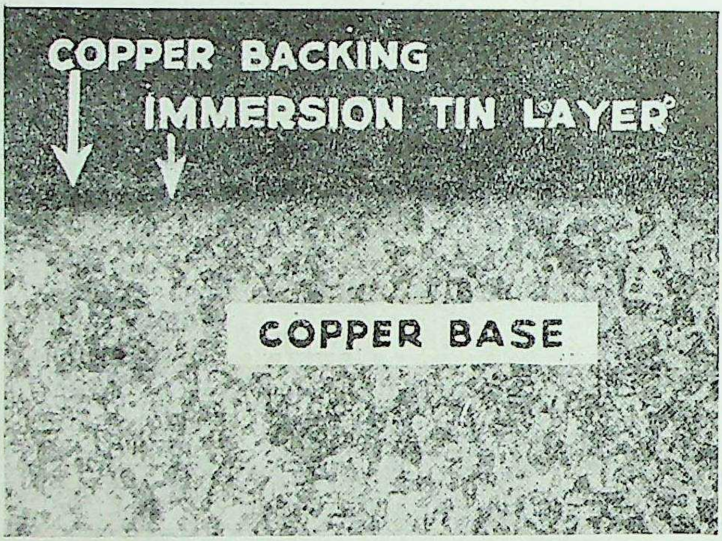

COPPER BACKING
IMMERSION TIN LAYER
COPPER BASE

Fig. 17

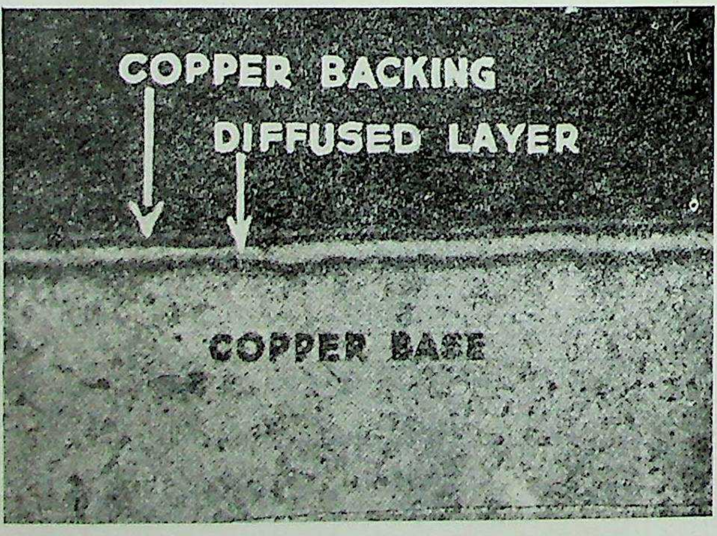

COPPER BACKING
DIFFUSED LAYER
COPPER BASE

Fig. 18

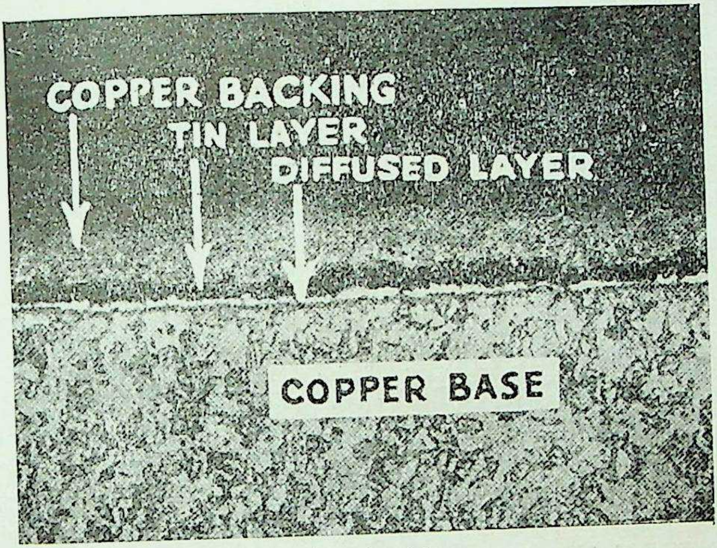

COPPER BACKING
TIN LAYER
DIFFUSED LAYER
COPPER BASE

Fig. 19

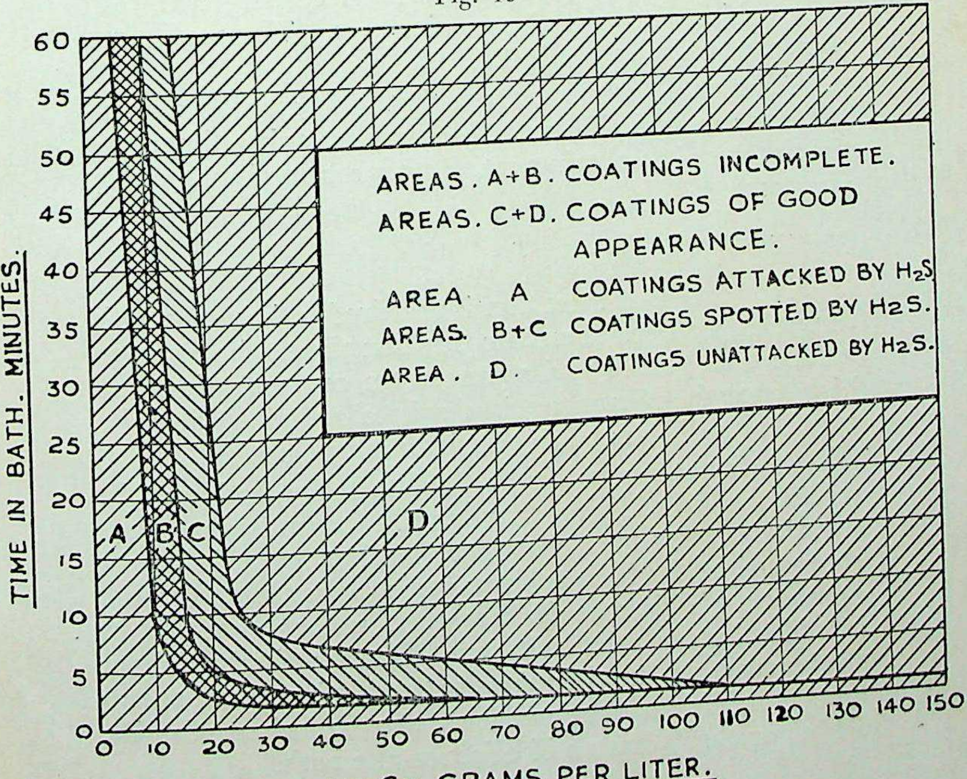

AREAS . A+B. COATINGS INCOMPLETE.
AREAS. C+D. COATINGS OF GOOD APPEARANCE.
AREA A COATINGS ATTACKED BY H2S
AREAS. B+C COATINGS SPOTTED BY H2S.
AREA . D. COATINGS UNATTACKED BY H2S.
A
B
C
D
TIME IN BATH. MINUTES.
0
5
10
15
20
25
30
35
40
45
50
55
60
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Na CN. GRAMS PER LITER.

Fig. 20

metric replacement of tin in the bath by copper dissolving from the metal. No external current is used. The electro-potential of copper is higher than of tin in NaOH, NaCN solution, and so metallic copper goes into solution and tin is converted by replacement to tin metal (Sn) which plates on the copper and brass articles.

Concentration of the bath

Tin : With NaCN constant at 50.0 g/l the concentration of tin as sodium stannite was varied from 0.5 to 17.0 g/l. Good bright deposits were obtained in all cases.

NaCN : Baths were prepared with sodium stannite held constant at 4.4 g/l and with the NaCN varying from 5 to 150 g/l. (The coated specimens were examined for appearance and completeness of tin coating and they were subjected to a H_2S corrosion test. The results are shown graphically in Fig. 20.

The data show, however, that high cyanide concentrations are desirable and that by employing them, the time required to obtain a satisfactory coating is noticeably decreased.

Stability of the bath

No particular attention is required to keep the bath in working order. Periodic titration should be made to ensure that NaCN and stannous tin concentrations are high enough. Stannous is slowly changed to stannite cyanide condition and in this form it will not coat.

As the stannous tin is depleted, the bath can be replenished by adding a stannous salt, for example sodium stannite or stannous chloride. Sodium cyanide is decomposed in the bath to form some carbonate and some cyanogen. This rate is, however, not as great as in cyanide electroplating solution. Copper dissolved from the brass or copper will not cause trouble in normal operations. Additions of as much as 50 g/l of either $CuSO_4$, 5 H_2O or $CuCl_2$ has no ill effect on the bath.

Sodium stannite is produced by the reaction :

$$SnCl_2+4\ NaOH = Na_2SnO_2+2\ NaCl+2\ H_2O$$

Here, NaOH solution is added slowly and with agitation to an aqueous solution of stannous chloride. After adding the sodium cyanide and diluting it with water to the required volume, the bath is ready for use.

Application

This process has wide application where a relatively thin coating of tin on copper or brass is requested. Tin, not only adds resistance to corrosion, but also gives coating, conductive to soldering. Novelty and luxurious articles, fixtures etc. can be given satisfactory coatings.

CHAPTER V

PERMANENT MOULDS

Introduction

According to American terminology, a permanent mould casting is one made in a metal mould that is poured under a gravity head and without centrifuging. Actually the word "Permanent" is intended to indicate that the mould serves for making long runs of castings (often many thousands). It is not necessary, as with sand casting to make a new mould for each casting or gate of castings, and it is this fact that makes a permanent mould casting more efficient in many cases, from a labour standpoint than a sand casting.

Most makers of permanent mould castings make also a secondary type often termed "Semi-Permanent" mould castings because the cores used are made from dry sand in core boxes exactly as are cores for the sand casting. If such types of moulds are introduced for domestic articles in this brass industry it will be a great boon to the industry.

Advantages and Limitations

The following are among the significant advantages of permanent mould castings :

(1) A single metal mould serves, as a rule for making from 3,000 to 25,000 or more castings; it is not necessary as with the sand casting, to make a new mould for each casting or gate of castings.

(2) Castings are dense and the rapid chilling makes for a favourable fine grain structure.

(3) In general, castings are smoother than sand castings and this favours appearance in addition to tending to lower machining and finishing costs.

(4) Production is rapid, as the casting chills quickly and can be ejected soon after pouring is completed.

(5) Dimensional tolerances can be held more closely than for sand castings, hence less allowance for machining is needed and total machining costs are below those for equivalent sand castings.

(6) In general, less metal is required per casting than for sand casting and less scrap results.

(7) Usually holes can be formed by metal cores and can be held within close dimensions; holes smaller than are feasible in sand casting often can be cored.

(8) Porosity is commonly the lowest for any form of casting (except perhaps for some centrifugal castings) and makes its use advisable to produce castings subject to fluid or gas pressure.

(9) Inserts often can be cast in place, whereas this seldom is possible in sand casting.

(10) Sizes that are larger than are practicable in die casting, can be made and alloys not suited for die casting, including ferrous alloys, can be used.

(11) The range of alloys available is wider than for die casting and some alloys can be heat treated with beneficial results not attained in die cast parts.

(12) Cores of certain shapes, especially sand cores, not feasible in die casting can be applied.

(13) As strength superior to sand casting can be attained, thinner walls for a given strength can be used (except, perhaps for thinnest sections castable) and corresponding metal economy can be attained.

(14) Moulds cost less than dies for die casting.

(15) In general, no casting machine is needed.

(16) Tooling costs, especially for machining, are often lower than for sand castings.

Limitations include

(1) Certain shapes that are practicable in sand casting or in die casting are not in permanent mould casting.

(2) Maximum size is less than that advisable to sand casting and greater (at least in some alloys) than for die casting. Minimum size is greater than for die casting.

(3) Minimum wall thickness is greater than for die casting and some other types of casting.

(4) Dimensional limits cannot be held as closely as with die casting.

(5) A considerable investment in moulds is required, usually more than for patterns for sand casting.

(6) Moulds are subject to considerable deterioration and involve significant expense in coating and other upkeep.

(7) Production rates usually are much below those for die casting.

(8) Where sand cores are required, core boxes are needed and or more cores must be made for each casting produced.

(9) Considerable experimental work, including changes in gating, is commonly needed before satisfactory casting are produced and the technique necessary to reduce rejects to a minimum is established.

(10) For large casting, some type of machine often is needed to operate moulds.

(11) Labour per casting (excluding that for making moulds) nearly always is higher per casting than for die casting.

(12) Smoothness of castings is not equal to that attained in die casting.

MOULD CONSTRUCTION

ALTHOUGH mould design usually does not directly concern the designer of the casting, the more he knows about the types of moulds employed, the better equipped he is to adapt the design of the casting to that of the mould. Most moulds (except for low melting alloys) are cast in meehanite or some similar alloy iron that is resistant to heat and to such dimensional changes as otherwise would result from repeated heating and cooling. In general, the cavities are cast fairly close to size but with allowance for machining to final size. As a rule mould walls range from 3/4″ to 2″ in thickness, when iron moulds are used and commonly follow the approximate contour of the casting. Mould sections have to be machined at partings, for metal cores and on surfaces that guide the motion of movable portions. Moulds always must be so shaped and parted that the casting can be removed quickly and without significant distortion when the mould is opened.

All moulds have to be locked before being filled but simple screw or toggle clamps are adequate for average small moulds.

Material Selection

Grey Iron

This material is extensively used for gravity moulds being cheap, rigid and free machining. The size and shapes feasible are somewhat limited, especially as only sand cores are used and they cannot be so small as metal cores, useable in many non-ferrous castings. Cast iron affords fairly good corrosion resistance, though subject to some red rust, and has fair bearing properties. Sections thinner than 1/8″ are seldom advised.

It is believed that the graphite content of this material is mainly responsible. The growth tendency is a definite disadvantage, and graphite size and distribution may vary considerably from one casting to another. These defects are avoided by the use of special irons. Perhaps the best known of these is 'Meehanite Metal.' The material may be considered as having the structure of a eutectoid steel in which fine graphite is uniformly distributed throughout. The photo-micrographs of ordinary grey iron and meehanite 'A' shown in Fig. 21

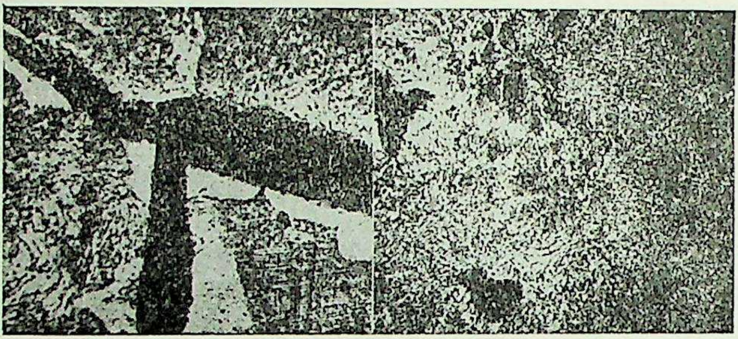


Fig. 21

illustrate clearly the marked differences in structure. The latter material is virtually non-growing and finds wide application in permanent moulds. Mild steel and monel metal are occasionally used, but are limited by the tendency to distortion.

ALLOY STEELS

The highly alloyed steels of nickel-chromium-tungsten type find some application in gravity mould work, but their specific properties are best utilised in pressure die casting. When correctly heat-treated they are non-shrinking and phenomenal lives are possible.

The production of metal components in sand and metal moulds falls into two groups and comparatively few articles lend themselves to both methods. A very interesting attempt to bridge the gap and to combine the best features of both systems is seen in British Patent 330, D18. Using carbonyl iron powder sintered to various densities, iron moulds may be made which are readily machinable having pores to promote venting, and can also be produced to definite thermal conductivity requirements.

DESIGN RULE

Details of mould design, construction and operation are important to producers of permanent mould castings.

The following rules are intended to serve as a guide and as an aid towards keeping costs at a minimum. Many of the rules cannot be followed in specific cases partly because it is often expedient to sacrifice something in economy to attain benefits in other directions considered more important.

(1) Keep size at the minimum consistent with other needs.

(2) Strive to attain uniformity in section thickness but, where variations in thickness are considered necessary or yield important benefits, see that the transition from thick to thin is gradual rather than abrupt.

(3) Avoid thick sections isolated by thin ones unless the thick section can be so located as to be readily filled.

(4) Keep all sections as thin as is compatible with adequate strength and stiffness and with reasonable ease in casting.

(5) Avoid couples structures unless assured that casting will be feasible and not involve undue expenses for moulds, cores and casting difficulties.

(6) Make full use of coring possibilities where assured that coring benefits will compensate fully for whatever can increase is involved.

(7) Make sure that the part to be cast is so shaped that it can be cast readily in a permanent mould.

(8) Employ ribs where necessary to stiffen walls or add strength but make sure that ribs are so proportioned, as not to be excessively stressed and are so placed that production of castings is not handicapped.

(9) Design the casting so that, consistent with other requirements, a mould having a minimum number of component parts can be used.

(10) Provide ample fillets at wall junctions but, where fillets of large radius are used, see that both faces

follow the same contour to avoid unnecessary metal concentrations.

(11) See that side walls and holes produced by metal cores have adequate draft to facilitate removal of castings from the mould and core removed.

(12) Avoid undercuts unless the benefits derived are known to offset whatever cost increase may be incurred.

(13) Where inserts cast in place appear to promise net benefits, make sure that their application is feasible and not excessive in cost.

(14) Never specify dimensional tolerances closer than are required or than are held on mating parts.

(15) Design the casting so that, subject to attainment of other desired objectives, flash removal costs will be minimized.

(16) Where a gear, cam, ratchet or similar part (that unless cast, must be cut at high cost from wrought stock) is needed, provide for casting is separately or as an integral part of some other casting.

(17) Where appearance is significant, see that external contours are pleasing and in keeping with mating parts.

PRACTICAL WORK*

An order was placed for 6 (Katori) moulds with Meehanite Division, Cooper Engineering Ltd., Satara Road, (Mahrasthra). Two sectioned drawings of the Katori and Gillas moulds are shown in Figs. 22 and 23. The different composition of brasses were melted in pit furnaces and were cast in the meehanite moulds to deoxidise the metal completely so that the casting is free from blow holes pure aluminium was added. The castings obtained were quite satisfactory. The pre-heating of

---

* This work was mostly carried out at the Cottage Manufacturing Centre, Moradabad.

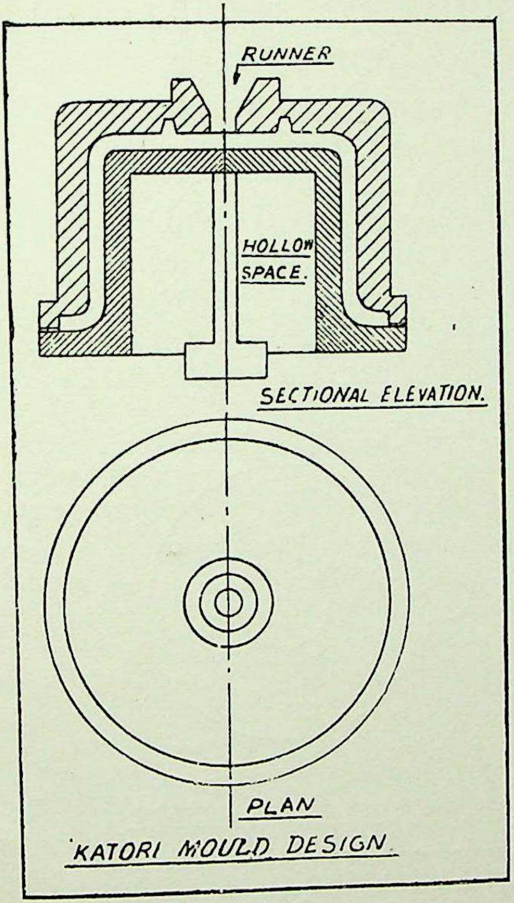

RUNNER
HOLLOW SPACE.
SECTIONAL ELEVATION.
PLAN
KATORI MOULD DESIGN.

Fig. 22

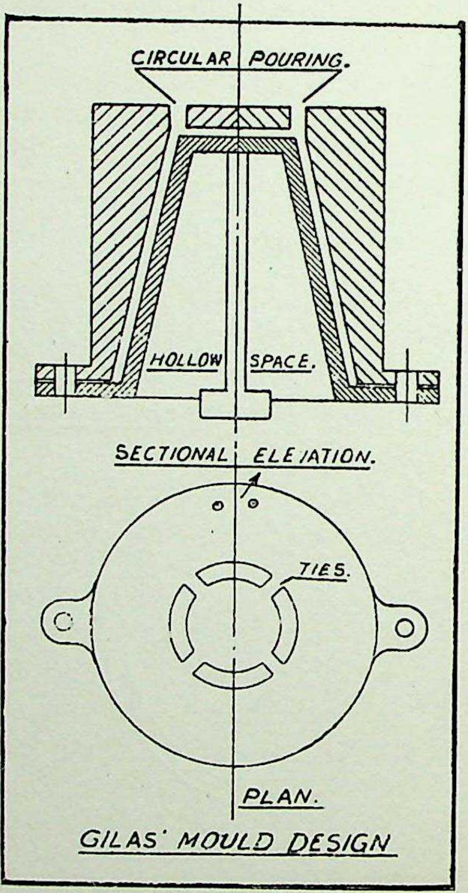

CIRCULAR POURING.
HOLLOW SPACE.
SECTIONAL ELEVATION.
TIES.
PLAN.
GILAS' MOULD DESIGN

Fig. 23

these moulds were necessary and the moulds were dressed with 'Pindool Mitti'.

In the upper parts of these moulds the brass billets were also cast and were rolled in local rolling mills and the rolled sheets were free from surface defects and were found to be suitable for deep drawing purposes.

CONCLUSION

Permanent mould castings are definitely intended for quantity production and constitute an important class of castings and the overall costs are often less per casting in the quantities required than for Sand Castings. This growth has been accelerated by high labour costs and labour scarcity for sand casting and the advantage is further increased in most cases because of lower machine charges for machining permanent mould castings as compared with sand castings.

REFERENCES

CHAPTER II

1. *Metal Industry,* November 1942, Vol. 61
2. —do— , December 29, 1939)
) Vol. 55
3. —do— , December 8, 1939)
4. *A Scheme of Design and Operation of Brass Foundry,* by S. C. Som.
5. *India's Self-Sufficiency in Non-ferrous Alloys.*
6. *Reclamation and Refining of Non-Ferrous Metal Scraps,* by M. N. Saxena.

CHAPTER III

Chemical Analysis

1. *Technical Analysis of Brass,* by Price and Meade.
2. *Metallurgical Analysis,* by V. G. Iyer, B.A., F.R.I.C.
3. *The Chemical Analysis of Tin and Lead Soft Solders,* Metal Industry, Fig. 21, 1940, Vol. 61.

Metallography

1. *Metals Hand Book.*
2. *Copper and Copper Base Alloys,* by Wilkins and Bunn.
3. *Principles of Metallography,* by Williams and Homerburg.
4. *Practical Microscopical Metallography,* by R. H. Greeves, D.Sc. and H. Wrighton, B. Met. 1946.
5. *The Metallurgy of Deep Drawing and Pressing,* by J. Dudley Jevons, Ph.D., B.Sc., A.I.C.

CHAPTER IV

1. Tin Research Institute, *Hot Tinning Publication No.* 102.
2. *Metal Industry,* June 28, 1940.

CHAPTER V

1. *Metal Industry* 20, 1948.
2. *Meehanite Bulletins* No. 23, No. 30 and No. 3.
3. *Materials and Methods,* Volume 28, No. 1, July 1948, page 75.
4. *Brass Industry of Moradabad,* Thesis by S. S. Khanna, 1948. for B.Sc. (Met) . Examination.

UTTAR PRADESH SCIENTIFIC RESEARCH COMMITTEE MONOGRAPHS

General Editor : Prof. SATYA PRAKASH

ULTRASONICS AND COLLOIDS
By SATYA PRAKASH AND ASHIM K. GHOSH

PHYSIOLOGICAL STUDIES ON SOME PATHOGENIC FUNGI
By R. N. TANDON

HORMONAL CONTROL OF PLANT GROWTH
By N. S. PARIHAR

DESIGN AND DEVELOPMENT OF ELECTRONIC INSTRUMENTS
By S. S. BANERJI

HYDRODYNAMIC SUPERPOSABILITY
By RAM BALLABH

GENERALISED HYPERGEOMETRIC SERIES
By R. P. AGARWAL

OPTICAL ACTIVITY AND CHEMICAL CONSTITUTION
By (Late) BAWA KARTAR SINGH & O. N. PERTI

BRASS INDUSTRIES OF UTTAR PRADESH
By S. S. KHANNA

EPIDIDYMIS OF BIRDS
By BHRIGUNATH PRASAD

CHEMICAL STUDY OF SOME INDIAN ARCHAEOLOGICAL ANTIQUITIES
By N. S. RAWAT AND SATYAPRAKASH

ASIA PUBLISHING HOUSE
BOMBAY · CALCUTTA · NEW DELHI · MADRAS
LUCKNOW · LONDON · NEW YORK